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NATIONAL DAM SAFETY PROGRAM, RIVER CEMENT CO. LAKE DAM (MO 3042-ETC(U)
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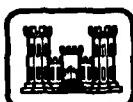
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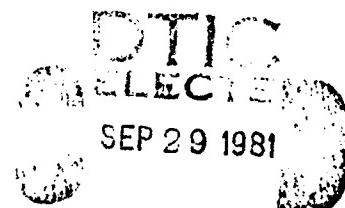
RIVER CEMENT CO. LAKE DAM
JEFFERSON COUNTY, MISSOURI
MO 30420

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM



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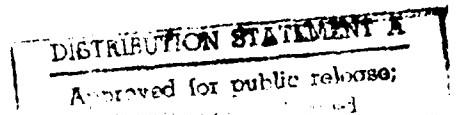
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DECEMBER 1979

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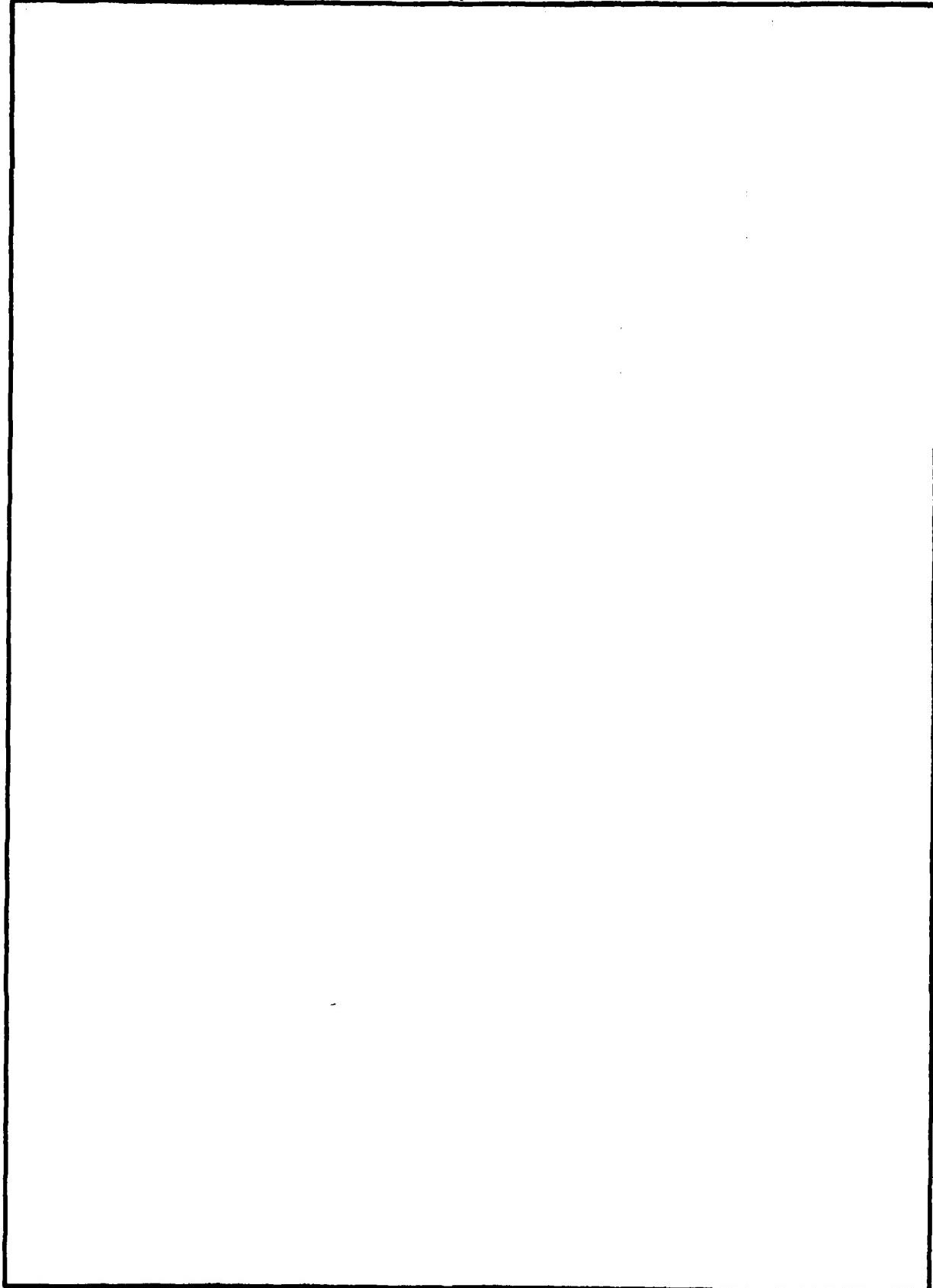


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20. ABSTRACT (Continue on reverse side if necessary and identify by block number) This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.		

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DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: River Cement Co. Lake Dam (Mo. 30420)

This report presents the results of field inspection and evaluation of the River Cement Co. Lake Dam. It was prepared under the National Program of Inspection of Non-Federal Dams.

SUBMITTED BY:

SIGNED

Chief, Engineering Division

28 DEC 1979

Date

APPROVED BY:

SIGNED

Colonel, CE, District Engineer

28 DEC 1979

Date

Inspection For	SI
Condition	Good
Recommendation	None
Comments	None
Inspection by	Colonel, CE, District Engineer
Inspection Date	28 DEC 1979
Signature	A

MISSISSIPPI - KASKASKIA - ST. LOUIS BASIN

**RIVER CEMENT CO. LAKE DAM
JEFFERSON COUNTY, MISSOURI
MO 30420**

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY PROGRAM



**United States Army
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St. Louis District

PREPARED BY: U. S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

DECEMBER 1979

RIVER CEMENT CO. LAKE DAM - MISSOURI INVENTORY 30420
JEFFERSON COUNTY, MISSOURI

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

HORNER & SHIFRIN, INC.
5200 OAKLAND AVENUE
ST. LOUIS, MISSOURI 63110

FOR:

U.S. ARMY ENGINEER DISTRICT, ST. LOUIS
CORPS OF ENGINEERS

DECEMBER 1979

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PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam:	River Cement Co. Lake Dam
State Located:	Missouri
County Located:	Jefferson
Stream:	Branch Cliffdale Hollow
Date of Inspection:	26 July 1979

The River Cement Co. Lake Dam, was visually inspected by engineering personnel of Horner & Shifrin, Inc., Consulting Engineers, St. Louis, Missouri. The purpose of this inspection was to assess the general condition of the dam with respect to safety and, based upon this inspection and available data, determine if the dam poses a hazard to human life or property.

The following summarizes the findings of the visual inspection and the results of certain hydrologic/hydraulic investigations performed under the direction of the inspection team. Based on the visual inspection, the present general condition of the dam is considered to be satisfactory. The following deficiencies were noticed during the inspection and are considered to have an adverse effect on the overall safety and future operation of the dam.

1. A minor collection of floating debris is lodged within the drop inlet spillway structure at the upstream end of the outlet pipe. An accumulation of debris within the spillway structure can obstruct the outlet pipe resulting in a loss of discharge capacity and unwarranted flooding of the lake. → *outlet pipe*

2. Several beaver dams exist within the downstream channel between the dam and the juncture of the channel with Cliffdale Hollow, a distance of about 1,000 feet. Damming of the channel is believed to be responsible for the tailwater pool that lies adjacent to the downstream toe of the dam. In addition, the outfall channel that lies between the outfall structure and the downstream channel is partially obstructed by small trees and brush. Obstructions within the downstream channel will reduce the discharge capacity of the outlet that could result in flooding of the area adjacent to the stream. The presence of the pool at the toe of the dam creates an unnecessarily high tailwater that reduces the effective weight of the dam which could impair the structural stability of the dam. The pool also prevents control of dam underseepage if such a condition exists.

According to the criteria set forth in the recommended guidelines, the magnitude of the spillway design flood for the River Cement Co. Lake Dam, which is classified as intermediate in size and of high hazard potential, is specified to be the Probable Maximum Flood (PMF). The Probable Maximum Flood (PMF) is the flood that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Results of a hydrologic/hydraulic analysis indicated that the existing spillways (principal & auxiliary) are adequate to pass lake outflow corresponding to 100 percent of PMF inflow. The principal spillway is by itself, adequate to pass the lake outflow corresponding to 100 percent of the PMF inflow. According to the St. Louis District, Corps of Engineers, the length of the downstream damage zone, should failure of the dam occur, is estimated to be three-fourths of a mile. Within the possible damage zone, is the River Cement Company complex.

It is recommended that the Owner take the necessary action in the near future to correct or control the deficiencies reported herein.

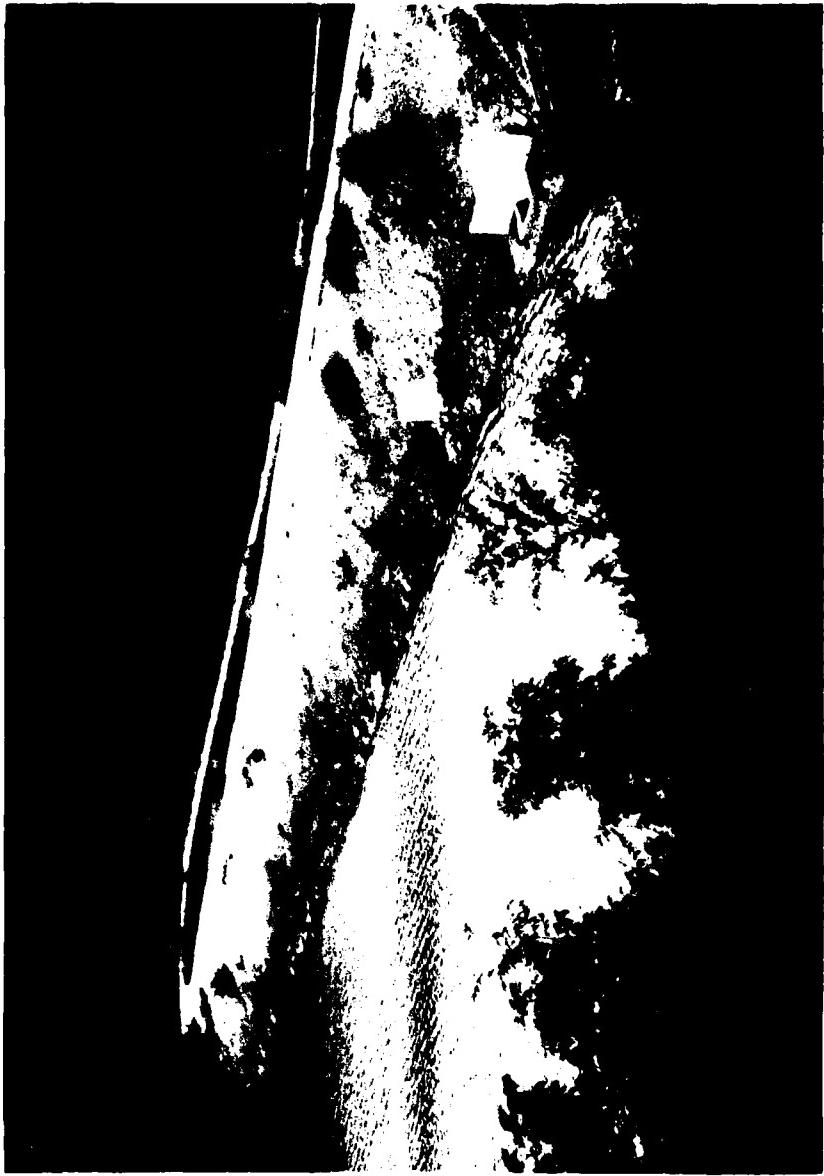
Karl L. Freese

P.E. Missouri E-16182

Albert B. Becker, Jr.

P.E. Missouri E-9168

OVERVIEW RIVER CEMETERY, LAKE DAM



PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

RIVER CEMENT CO. LAKE DAM - ID. NO. 30420

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*Construction Plans prepared by Horner & Shifrin, Inc., 1964.

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PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM

RIVER CEMENT CO. LAKE DAM - ID NO. 30420

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. National Dam Inspection Act, Public Law 92-367, dated 8 August 1972, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the St. Louis District, Corps of Engineers, directed that a safety inspection of the River Cement Co. Lake Dam be made.

b. Purpose of Inspection. The purpose of this visual inspection was to make an assessment of the general condition of the dam with respect to safety and, based upon available data and this inspection, determine if the dam poses a hazard to human life or property.

c. Evaluation Criteria. This evaluation was performed in accordance with the "Phase I" investigation procedures as prescribed in "Recommended Guidelines for Safety Inspection of Dams," Appendix D to "Report of the Chief of Engineers on the National Program of Dams," dated May 1975.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances. The River Cement Co. Lake Dam is a zoned earth and rockfill embankment rising approximately 57 feet above the original streambed. The embankment has an upstream slope of 1v on 2.5h, a crest width of about 20 feet, and a downstream slope of 1v on

2h that flattens to 1v on 3h at a level about 41.5 feet below the top of the dam. A 6-foot wide berm is located on the upstream face of the dam at a level about 30.5 feet below the top of the dam. The length of the dam, including the auxiliary spillway is approximately 605 feet. A road surfaced with crushed stone traverses the top of the dam. A plan of the dam showing topography and various site improvements is presented on Plate 4. A profile of the dam and selected cross-sections of the embankment are shown on Plate 5. (Plates 3 through 9 are reproductions of original drawings prepared by Horner & Shifrin in 1964 for construction of the dam. Information shown on these drawings, was, to the extent possible, verified by survey at the time of the inspection, and found to be reasonably correct.) At normal pool elevation, the reservoir impounded by the dam occupies approximately 18 acres.

A drop inlet type spillway, located in the upstream face of the embankment near the right or east abutment, serves as the principal spillway for lake outflow. Flow from the drop inlet structure passes through a 36-inch diameter pipe to an outfall structure located approximately 175 feet below the dam. Discharge from the outfall structure joins the downstream channel approximately 100 feet below the structure. Details of the outfall structure are shown on Plate 6.

An auxiliary spillway, a broad-crested, trapezoidal section founded on bedrock, is located in the right abutment. The channel below the spillway crest is unimproved, however, spillway flow is conducted away from the dam. Details of the auxiliary spillway are shown on Plate 4.

A gatewell structure containing valves for control of lake water intake lines used by the Owner in the cement manufacturing process is also located in the upstream face of the embankment, approximately 60 feet west of the drop inlet spillway structure. A 14-inch diameter lake drain (drawdown) pipe also enters the structure where it is controlled by a valve before continuing as an 18-inch diameter pipe to the outfall structure. A second valve near the outfall structure allows flow in the 18-inch line to be discharged to waste or diverted to the plant. In

order to make up water removed from the impoundment for process use, flow is pumped through a 14-inch diameter pipe to the lake from the Mississippi River. The river influent line enters the reservoir on the west side of the lake.

b. Location. The dam is located on a south branch of Cliffdale Hollow approximately three-fourths of a mile upstream of the Mississippi River and within the industrial complex owned and operated by the River Cement Company. The access road to the plant is located at the northeast corner of the intersection of Interstate Highway 55 and U.S. Highway 61 in Jefferson County. The Dam is located in Jefferson County and lies within Section 22, Township 40 North, Range 6 East.

c. Size Classification. The size classification based on the height of the dam and storage capacity, is categorized as intermediate. (Per Table 1, Recommended Guidelines for Safety Inspection of Dams.)

d. Hazard Classification. The River Cement Co. Lake Dam, according to the St. Louis District, Corps of Engineers, has a high hazard potential, meaning that if the dam should fail, there may be loss of life, serious damage to homes, extensive agricultural, industrial and commercial facilities, important public utilities, main highways, or railroads. The estimated flood damage zone, should failure of the dam occur, as determined by the St. Louis District, extends three-fourths of a mile below the dam. Within the possible damage zone is the River Cement Company complex.

e. Ownership. The lake and dam are owned by the River Cement Company; the address of which is: River Cement Company, Selma Plant, Festus, Missouri 63028. The Owner's representative is Mr. Robert H. Lamp, Plant Manager.

f. Purpose of Dam. The dam impounds water for use by the Owner in the process of manufacturing cement.

g. Design and Construction History. The dam was designed in 1964 by Horner & Shifrin, Inc., Consulting Engineers, under subcontract to the MacDonald Engineering Co. of Chicago, Illinois. The MacDonald Engineering Co. was retained by the Owner for design of the Selma Cement Plant. The builder of the dam was the Bloomsdale Excavating Co., Inc. of Bloomsdale, Missouri. Construction of the dam was completed in 1965.

h. Normal Operational Procedure. The lake level is unregulated.

1.3 PERTINENT DATA

a. Drainage Area. The area tributary to the lake is in a native state covered with timber. The watershed above the dam amounts to approximately 263 acres. The watershed area is outline on Plate 2.

b. Discharge at Damsite.

- (1) Estimated known maximum flood at damsite ... 50 cfs* (W.S.
Elev. 456.0)
- (2) Spillway capacity (principal) ... 170 cfs (W.S.= Elev. 460.0)
- (3) Spillway capacity (principal + auxiliary) ... 2,580 cfs
(W.S. = Elev. 466.4)

c. Elevation (Ft. above MSL). The crest of the drop inlet spillway structure shown on the construction plans prepared by Horner & Shifrin, Inc., is indicated to be elevation 455.0 (Ft. above MSL). This elevation, assumed to be correct, was used as a bench mark for surveys performed by the inspection team.

- (1) Top of dam ... 466.4 (min.)
- (2) Normal pool (spillway crest) ... 455.0
- (3) Streambed at centerline of dam ... 410+
- (4) Maximum tailwater ... Unknown
- (5) Tailwater at time of inspection ... 409.4

*Based on an estimate of high water level as observed by a representative of the Owner.

d. Reservoir.

- (1) Length at normal pool (Elev. 455.0) ... 2,300 ft.
- (2) Length at maximum pool (Elev. 466.4) ... 2,700 ft.

e. Storage.

- (1) Normal pool ... 300 ac. ft.
- (2) Top of dam (incremental) ... 295 ac. ft.

f. Reservoir.

- (1) Normal Pool ... 18 acres
- (2) Top of dam (incremental) ... 7 acres.

g. Dam. The structural height of the dam is defined to be the overall vertical distance from the lowest point of foundation surface to the top of the dam.

- (1) Type ... Zoned, clay core*
- (2) Length ... 605 ft. (including auxiliary spillway)
- (3) Structural Height ... 57 ft.
- (4) Top width ... 20 ft.
- (5) Side slopes
 - a. Upstream ... lv on 2.5h (6 ft. wide berm at Elev. 436.0)*
 - b. Downstream ... lv on 2h (above Elev. 425.0),
lv on 3h (below Elev. 425.0)
- (6) Cutoff ... Clay core*
- (7) Slope protection
 - a. Upstream ... Limestone Riprap
 - b. Downstream ... Limestone

h. Principal Spillway.

- (1) Type ... Uncontrolled, drop inlet structure
- (2) Location ... Upstream face near right abutment
- (3) Crest ... Elevation 455.0
- (4) Approach channel ... Lake

*Per construction plans by Horner & Shifrin, Inc.

- (5) Outlet ... 36-Inch diameter pipe
- (6) Elevation outlet pipe
 - a. Upstream ... 443.0 (Drop inlet structure)
 - b. Downstream ... 419.2 (Outfall structure)

i. Auxiliary Spillway.

- (1) Type ... Uncontrolled, rock cut, broad-crested, trapezoidal section
- (2) Location ... Right abutment
- (3) Crest ... Elevation 460.0
- (4) Approach channel ... Lake
- (5) Exit channel ... Unimproved

j. Lake Drawdown Facility.

- (1) Size ... 14-Inch ductile-iron pipe* from lake to gatewell; 18-inch ductile-iron pipe from gatewell to outfall structure
- (2) Control ... Valves at gatewell and outfall structure.
- (3) Elevation outlet pipe
 - a. Upstream ... 420.0 (Lake)
 - b. Downstream ... 419.0 (Outfall structure)

*Per Specification by Horner & Shifrin, Inc.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

a. Subsurface Investigations. Test borings were drilled at selected locations along the centerline of the dam by the Test Boring Department of the Raymond Concrete Pile Division, under the direction of Horner & Shifrin. The logs of these borings, five in all, along with the results of pressure tests performed at borings 3 and 4 are shown on Drawing No. I-7, reference Plate 9, of the construction plans. Overburden as indicated on the boring logs was classified according to the Unified Soil Classification System. The results of the tests on samples of overburden to determine natural moisture content and in-place dry density as well as the results of standard penetration tests is shown in the columns to the left of each boring. Also shown is the results of coring bedrock in terms of amount cored and percent recovered.

Soil samples were also obtained from nearby borrow areas that were used as a source of material for construction of the dam core. Atterberg limits tests performed on samples of borrow material indicated the soil to be a silty, lean clay of low to medium plasticity. Hydrometer tests were also performed to determine grain size distribution.

b. Dam. The dam was designed as a zoned earth and rockfill embankment. The minimum width of the seepage cutoff core was specified to be 20 feet. A graded filter was used to protect the core material and a filter blanket was placed below the rockfill on the downstream side of the dam to allow for drainage of seepage through the earthfill without loss of earth material. Details of the embankment design are shown on Drawing No. I-3, reference Plate 5, of the construction plans.

The present whereabouts of the design records of the dam are unknown. According to the design engineer, Wayne E. Ferree, who no longer is with Horner & Shifrin, seepage and stability analyses,

including earthquake loads, were performed and the dam was determined to be stable with normal allowances for safety.

c. Spillway. A drop inlet type spillway with a 36-inch diameter pipe outlet was designed to provide relief for lake surcharge occurring during normal service conditions. An outfall structure, with provisions to dissipate flow discharge energy, was provided at the downstream end of the outlet pipe. An auxiliary spillway was also provided, to accommodate lake outflow during storms of high runoff intensity. According to Vance C. Lischer, project engineer for Horner & Shifrin, at the time of the design, the spillways for this dam were designed for the probable maximum flood. Details of the drop inlet spillway structure and the downstream outfall structure for the 36-inch diameter pipe are shown on Drawings Nos. I-4 and I-5, reference Plates 6 and 7, respectively.

d. Appurtenances. A system of lake intake lines was designed to provide process water to the plant. A lake drain line that can also be used for process water, was provided and a gatewell structure was designed to house valves for control of these lines. Details of the gatewell structure are shown on Drawing No. I-6, reference Plate 8, of the construction plans. Details of pipe supports and lake intake screens are also shown on Drawing No. I-6.

2.2 CONSTRUCTION

As previously indicated, the dam was constructed by the Bloomsdale Excavating Company of Bloomsdale, Missouri. Surveillance of construction activities was performed by Horner & Shifrin under subcontract to the MacDonald Engineering Company.

Records kept during construction of the dam, indicated that the seepage cutoff trench was carried to about elevation 400 at the center of the dam. Specifications for construction of the dam indicated that the earth-fill for the embankment was to be placed in lifts not to exceed

6 inches in thickness after compaction, and that each lift was to be compacted to a minimum of 90 percent of the maximum dry density as determined by the standard compaction test, ASTM D 698. A review of construction records indicated that 203 compaction tests were made and that 45 of these tests were less than 90 percent, 158 were greater than 90 percent, and that the average of all tests was 92.3 percent. Specifications also required that all rockfill used in the embankment should be either Platten limestone or Joachim dolomite, as indicated on the plans, and that filter rock and riprap rock should be Platten limestone. Rock for riprap was specified to be reasonably well-graded in sizes from 25 to 100 pounds in weight. Riprap observed at the time of the inspection, appeared to conform to these size requirements.

2.3 OPERATION

a. General. The lake level is uncontrolled and governed by the crest elevation of the drop inlet spillway structure. According to information provided by a representative of the Owner, the dam has never been overtopped and the highest lake level observed to date produced a rise in the lake surface above normal pool estimated to be about 12 inches.

b. Previous Inspections. In March of 1974 and at the request of the Owner, Horner & Shifrin engineering personnel inspected the dam to determine the cause of a leak that had developed in the downstream face of the dam near the right abutment at a point approximately half way down the embankment. At the time the leak was estimated to be flowing at a rate of about 5 to 10 gpm and was clear. Laboratory analyses of the leakage indicated it to be of the same composition as water from the lake. Since it was concluded that the leak posed no imminent danger to the safety of the dam and since the volume of leakage was not considered excessive, Horner & Shifrin recommended that the leak be monitored over the next several months in order to determine increases in flow or turbidity. Horner & Shifrin was not informed of further developments with regard to this leak.

A report prepared by Thomas J. Dean, Geologist, Missouri Geological Survey, written on December 27, 1974, reference Charts 2-1 and 2-2, and based on an examination of the dam and reservoir, indicated that without constant inflow of water to the lake, the lake level drops. Mr. Dean states, however, that no obvious leaks were noted downstream of the dam or resurgence of water in valleys to the east. He also mentions that due to the fact that the parent bedrock, Joachim dolomite, are dipping rapidly to the east at a rate of approximately 150 feet per mile, and that if water is being lost in the bedrock below the lake waterline, it probably would not resurge prior to its entry into the Mississippi River.

The report states that there are two probable sources of leakage from the lake. One source of leakage would be via the trenches provided for the lake inlet and outlet pipes. The second source of leakage would be horizontal leakage through bedrock in an eastward direction. Methods were recommended to determine the location of the leak based on these possible sources.

Mr. Dean also mentions that the lake setting is on the flank of a geologic structure that could have caused fracturing in the bedrock beneath the lake, and that a joint or vertical crack in the bedrock could allow water to escape and may be a single point source of water leakage.

A field investigation of an excavation on the north (actually northwest) side of the lake was made on November 24, 1976, by John W. Whitfield, Geologist, also with the Missouri Geological Survey. Subsequently, a file report, reference Chart 2-3, dated January 14, 1974, was prepared. The report mentions that the excavation was made at the location of a small sinkhole that had appeared in the silty clay surface soils just above the waterline on the north (northwest) edge of the lake.

The excavated trench exposed a weathered limestone that contained a horizontal solution enlarged joint and there was evidence that lake water

was entering the joint opening. The report states that it was recommended that the joint be sealed with concrete and that grout be pressure injected into the joint opening. A representative of the Owner reported that the joint was sealed as recommended and the lake level stabilized. According to the Owner's representative, to date, no additional problems related to loss of water from the lake have occurred.

2.4 EVALUATION

a. Availability. Engineering analyses for assessing the design of the dam are unavailable. Data available are limited to information shown on the construction plans and in the specifications prepared by Horner & Shifrin in 1964.

b. Adequacy. Since it has been verified that seepage and stability analyses, including earthquake loads, were made, and since the findings of the visual inspection revealed no evidence of instability, no further structural analyses of the dam are considered necessary.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of the River Cement Company Lake Dam was made by Horner & Shifrin engineering personnel, K.L. Freese, Civil Engineer, and Hydrologist, and A.B. Becker, Jr., Civil and Soils Engineer, on 26 July 1979. An examination of the dam site was also made by an engineering geologist, Jerry D. Higgins, a consultant retained by Horner & Shifrin for the purpose of assessing the area geology. Also examined at the time of the inspection, was the immediate area below the dam within the potential flood damage zone. Photographs of the dam taken at the time of the inspection are included on Pages A-1 through A-4 of Appendix A.

b. Area Geology. The dam site and lake are located on the northern flank of the Ozark Uplift on gently dipping (eastward) Ordovician age sedimentary rock. In the general site area, the Ordovician age Joachim and Plattin formations are exposed at the surface. The Joachim is predominantly a yellowish-brown, argillaceous dolomite with some interbedded limestone and shale. The Plattin is composed of evenly bedded, gray, finely crystalline to micritic limestone with minor amounts of intercalated shale.

The dam site and lake are founded on lower Plattin (or possibly upper Joachim) limestones and shales covered with a shallow layer of unconsolidated materials, principally a clay residuum mixed with modified loess. Bedrock of the Plattin (Joachim) formation is well exposed in the rock cut for the auxiliary spillway in the right abutment. Although the Plattin and Joachim formations exhibit solution weathering features in some areas of eastern Missouri, no karst features were evident in the reservoir and dam area, and bedrock in the spillway did not appear to be highly solution weathered.

The abutments are steeply sloping, composed of bedrock and a thin veneer of unconsolidated materials. The slopes appear stable and show no signs of seepage or severe erosion. No adverse geologic conditions conducive to leakage or dam failure were evident at the site.

c. Dam. The visible portions of the limestone covered upstream and downstream faces of the dam (see Photos 1 and 2) appeared to be in sound condition. No vertical cracks or misalignment of the dam crest was evident. The road surfaced with crushed stone that serves the dam crest was found to be in good condition. Several small trees were observed growing in the downstream face of the dam near the sides of the embankment. Stone riprap up to 1 cubic foot in size serves to protect the upstream face of the dam. The drainage ditch at the downstream toe of slope at the left side of the dam has been lined with rock apparently to prevent erosion of the earthen surface at the abutment. Examination of the downstream slope of the embankment did not reveal any signs of seepage through the face of the dam or at the abutments. Due to the existence of a pool of water that abuts the downstream toe near the center of the dam, (see Photo 7) it could not be determined if the dam was experiencing underseepage.

The concrete drop inlet spillway, the gatewell, and the spillway outfall structure (see Photos 3 and 4) were examined and found to be in excellent condition without cracks or spalls due to weathering. A minor accumulation of lake-carried debris was noticed in the drop inlet at the upstream end of the 36-inch outlet pipe. Small trees and brush were present in the spillway outfall channel and some erosion of the riprap lining for the channel invert, particularly at the end of the outfall structure, has occurred.

The auxiliary spillway (see Photos 5 and 6) was examined and found to be in excellent condition as was the concrete sill at the upstream end of the spillway crest. The spillway outlet channel is unimproved, however, spillway releases will be conducted away from the dam.

d. Downstream Channel. The channel downstream of the dam is unimproved, although a concrete wall has been constructed across the stream at a location approximately 1,200 feet below the dam. According to a representative of the Owner, the purpose of the wall is to dam the stream and create a source of additional plant process water.

Several beaver dams (see Photo 8) were noticed within the downstream channel between the dam and the junction of the channel with Cliffdale Hollow, a distance of about 1,000 feet. Damming of the channel by beavers is believed to be responsible for the pool of water that lies adjacent to the downstream toe of the dam. Examination of the channel below the last beaver dam, approximately 900 feet from the dam, showed no continuing stream flow.

e. Reservoir. The area surrounding the lake is in a natural state, covered with timber. According to a representative of the Owner, the screens at the intake ends of the pipelines extending into the reservoir have in the past covered over with debris and periodically have to be unclogged.

3.2 EVALUATION

The deficiencies observed during this inspection and noted herein, are not considered significant to warrant immediate remedial action.

Although the elevations of the settlement gages installed in the dam crest at the time of construction were not obtained at the time of the inspection, it is possible that the dam has experienced some settlement. A survey of the dam crest indicated the top of the embankment at the center of the dam to be approximately elevation 466.4. Construction plans, reference Plate 5 (Sheet I-3), indicate the top of the proposed embankment to be elevation 466.5 and that the crushed stone for the road section installed above the fill to be 9 inches thick at the roadway

center. Although it is likely that some of this roadway fill has been displaced laterally, there is reason to believe that some minor settlement, on the order of 0.5 foot, has occurred at the center of the dam. However, settlement of this magnitude is not considered significant.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The spillway is uncontrolled. The water surface level is governed by precipitation runoff, pumping (inflow), outflow for process use, evaporation, seepage, and the capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

With the exception of the downstream channel where flow is obstructed by several beaver dams, and based on the general condition of the dam as determined at the time of the inspection, it is apparent that the dam and appurtenances are well maintained.

4.3 MAINTENANCE OF OUTLET OPERATING FACILITIES

Except for pipelines for intake of process water and a lake drain line, no outlet operating facilities exist at this dam.

4.4 DESCRIPTION OF ANY WARNING SYSTEMS IN EFFECT

The inspection did not reveal the existence of a dam warning system.

4.5 EVALUATION

A well maintained dam is considered beneficial to the safety of the dam. It is recommended that maintenance of the dam also include the downstream channel.

SECTION 5 - HYDROLOGIC/HYDRAULIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data are not available. Procedures and data for determining the probable maximum flood, the 100-year frequency, and the discharge rating curve for flow passing the spillways and the dam crest are presented on Pages B-1 and B-2 of the Appendix.

b. Experience Data. The drainage area and lake surface area were developed from the USGS Selma, Illinois-Missouri, Quadrangle Map. The proportions and dimensions of the dam and spillways were developed from surveys made during the inspection, supplemented by information shown on the original construction plans.

c. Visual Observations.

(1) The principal spillway consists of a 4-foot square drop inlet with a 36-inch diameter pipe outlet. The spillway allows inflow from three sides. Flow entering the inlet from the fourth side is prevented by a concrete wall that rises 4 feet above the lip of the inlet.

(2) The drop inlet spillway is located in the embankment near the right (east) abutment.

(3) The 36-inch diameter drop inlet outlet pipe conducts lake outflow to an outfall structure located approximately 175 feet downstream of the center of the dam. The outfall structure, in turn discharges into a riprapped lined, trapezoidal channel that joins the original stream at a point about 100 feet below the structure.

(4) The auxiliary spillway consists of a 50-foot wide, U-shaped channel cut into rock at the hillside east of the embankment. The auxiliary spillway discharges into a natural draw below the dam.

(5) Discharges from the principal and auxiliary spillways will not endanger the integrity of the dam.

(6) The lake can be dewatered by a 14-inch screened drain pipe that discharges into the drop inlet spillway outfall structure.

d. Overtopping Potential. Elevation 466.4 was found to be the lowest point in the dam crest. The spillways (principal and auxiliary) are adequate to pass the probable maximum flood without overtopping the dam. The results of a dam overtopping analysis are as follows:

<u>Ratio of PMF</u>	<u>Q-Peak</u> <u>Outflow (cfs)</u>	<u>Max. Lake</u> <u>W.S. Elev.</u>	<u>Max. Depth of</u> <u>Flow over Dam</u> <u>(Elev. 466.4)</u>	<u>Duration of</u> <u>Overtopping</u> <u>Of Dam(Hrs)</u>
0.50	685	462.5	0.0	0.0
1.00	2,528	466.4	0.0	0.0
100-Yr.Flood	98	456.8	0.0	0.0

e. Evaluation. The results of an overtopping analysis indicates that the existing spillways are capable of passing lake outflow during the PMF condition although the level of the lake will very nearly reach the low point in the dam crest. However, should minor overtopping occur during this condition, damage to the downstream face of the dam is expected to be minimal due to the fact that the material subjected to flow is a well graded and compacted rockfill.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations which adversely affect the structural stability of the dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. Although it was verified that design analyses, including hydrological and seepage and stability analyses, of the dam were made, the present location of these records is unknown. Construction data relative to the structural stability of the dam is limited to records of density tests performed on earth fill for compaction control.

c. Operating Records. Flow is pumped from the Mississippi River through a 14-inch diameter pipe as necessary to maintain the level of the reservoir. An 18-inch diameter pipe that also serves as a lake drain line, (the flow can be diverted to an outlet located at the outfall structure) allows gravity flow to the plant complex for process use. Except for the influent and effluent lines mentioned herein, no other appurtenant structures or facilities requiring operation exist at this dam. According to a representative of the Owner, no records are kept of the lake level, spillway discharge, dam settlement, or seepage. Records are kept of water usage.

d. Post Construction Changes. According to a representative of the Owner, with the exception of sealing a leak at a highly permeable solution enlarged limestone joint at the shoreline along the north edge of the reservoir, no post construction changes have been made which would affect the structural stability of the dam.

e. Seismic Stability. Since the dam is located within a Zone II seismic probability area, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dam.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. A hydraulic analysis indicates that the spillways (drop inlet plus auxiliary) are capable of passing lake outflow of about 2,580 cfs without the level of the lake exceeding the low point in the top of the dam. A hydrologic analysis of the lake watershed area, as discussed in Section 5, paragraph 5.1d, indicated that for storm runoff of probable maximum flood magnitude, the lake outflow would be on the order of 2,528 cfs, and that for the 1 percent chance (100-year frequency) flood, the lake outflow would be about 98 cfs.

Items noticed during the inspection that could adversely affect the safety of the dam include the minor accumulation of debris within the drop inlet spillway and the presence of several beaver dams that obstruct the spillway outlet channel just below the dam. The tailwater pool that abuts the downstream toe of the dam is believed to be a result of blockage of the stream by the uppermost beaver dam.

Stability and seepage analyses of the dam were not available for review. However, according to information provided by the design engineer, these analyses were performed and the dam was determined to be stable with normal allowances for safety.

b. Adequacy of Information. Due to the fact that design data was unavailable for review, the assessments reported herein were based largely on external conditions as determined during the visual inspection and information provided by the design engineer. The assessment of the hydrology of the watershed and capacity of the spillways was based on a hydrologic/hydraulic study as indicated in Section 5.

c. Urgency. The remedial measures recommended in paragraph 7.2 should be accomplished within a reasonable time.

d. Necessity for Phase II. Based on the results of the Phase I inspection, a Phase II investigation is not recommended.

e. Seismic Stability. Since the dam is located within a Zone II seismic probability area, an earthquake of the magnitude predicted is not expected to produce a hazardous condition to the dam.

7.2 REMEDIAL MEASURES

a. Recommendations. It has been verified that seepage and stability analyses of the dam were made and therefore no further design analyses are considered necessary.

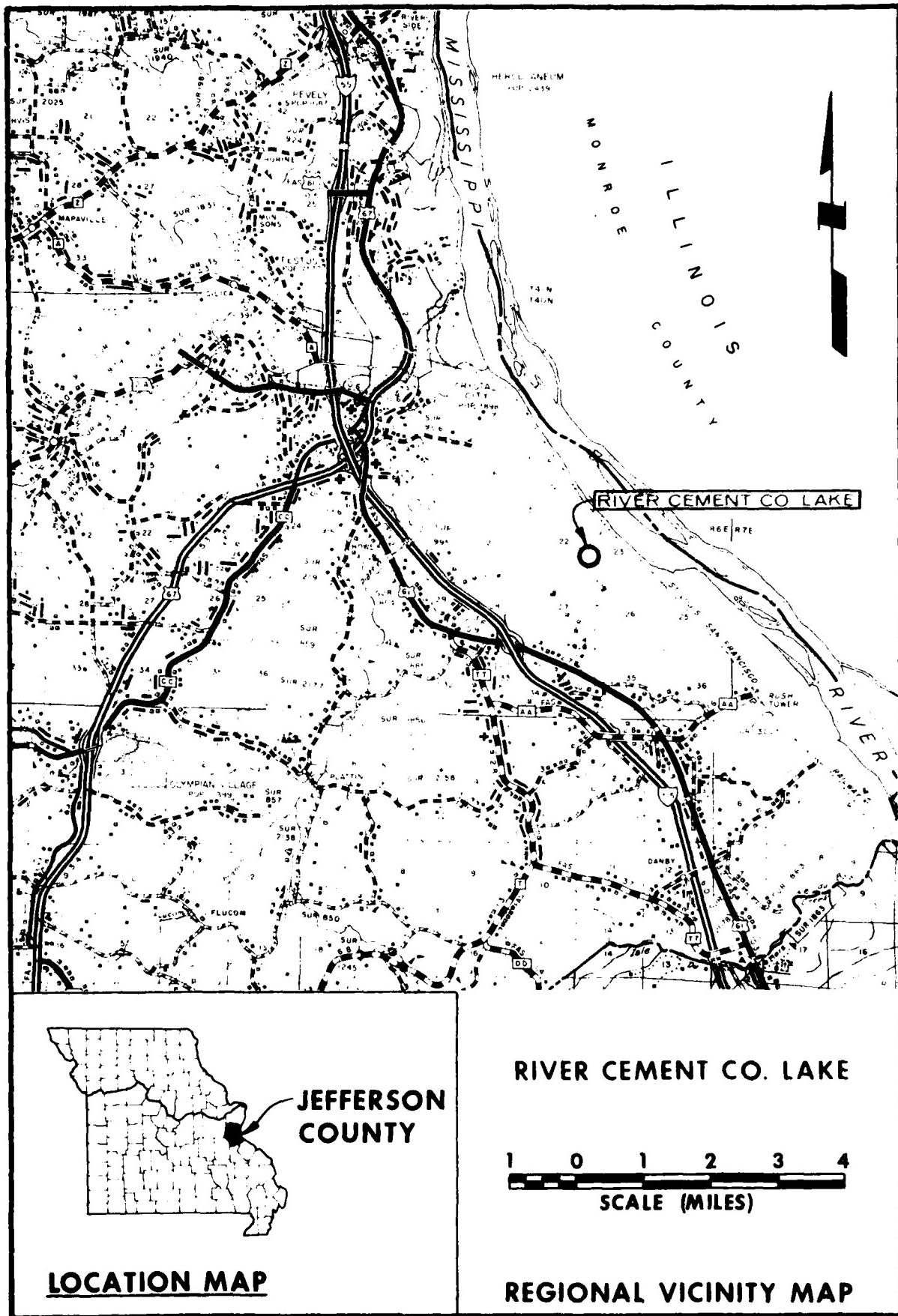
b. Operations and Maintenance (O & M) Procedures. The following O & M Procedures are recommended:

(1) Remove the debris lodged with the drop inlet spillway that obstructs the outlet pipe. An obstructed outlet can reduce the discharge capacity or possibly negate the spillway.

(2) Remove the beaver dams from the downstream channel that reduce the discharge capacity of the stream and which could result in flooding of the area below the dam. In any event, the pool at the toe of the dam should be drained to eliminate an unnecessary tailwater condition, which is considered detrimental to the stability of the dam. The small trees and brush present in the spillway outlet channel below the outfall structure should also be removed, since their presence restricts flow in the channel which could also result in flooding of the area below the dam.

(3) Provide maintenance of all areas of the dam, spillway and outlet channel on a regularly scheduled basis in order to insure these features being in satisfactory operational condition.

4) A detailed inspection of the dam should be instituted on a regular basis by an engineer experienced in the design and construction of dams. It is also recommended, for future reference, that records be kept of all inspections made and remedial measures taken.



LOCATION MAP

REGIONAL VICINITY MAP

PLATE I

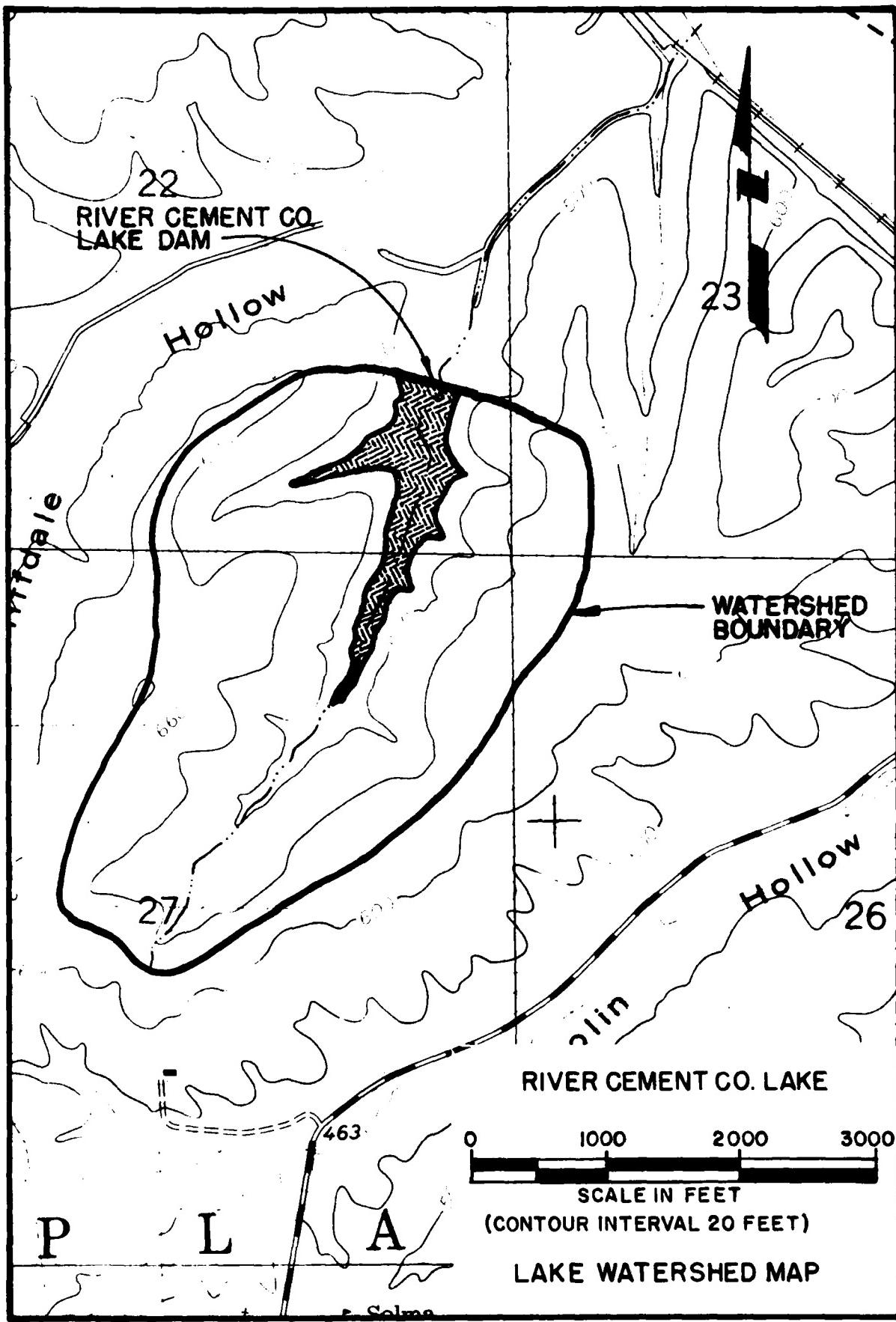


PLATE 2



RIVER CEMENT CO.
PROCESS WATER IMPOUNDMENT
INDEX OF DRAWINGS

<u>DWG. NO.</u>	<u>DESCRIPTION</u>
I-1	SITE MAP & DRAWING INDEX
I-2	GENERAL PLAN
I-3	CROSS SECTIONS & PROFILE OF DAM
I-4	DROP INLET SPILLWAY & ACCESS ROAD DETAILS
I-5	OUTFALL STRUCTURE
I-6	GATEWELL & PIPING DETAILS
I-7	FOUNDATION BORING PROFILE

404-144-0014 - 00 ACROSS
REAL ESTATE AND ALCOHOLIC
SUPPLIES

EXISTING TAKEWATER CHANNELS

$0.00 N$ } PLANT COORDINATES
 $0.00 S$
 $11,400 E$ } TRUE COORDINATES
 $0.000 E$

~~ROCK SOURCE (PLUTON LUMBER
PREVIOUSLY STOCKPILED)
OTHER PLANT CONSTRUCTION
ELEVATION ABOVE 900.0'~~

PROPOSED LOCATION OF
STOCKYARD CO. GIVES SAND TO
BE PLANNED BY RIVER CHANNEL

MENT

DAM

PAD DETAILS

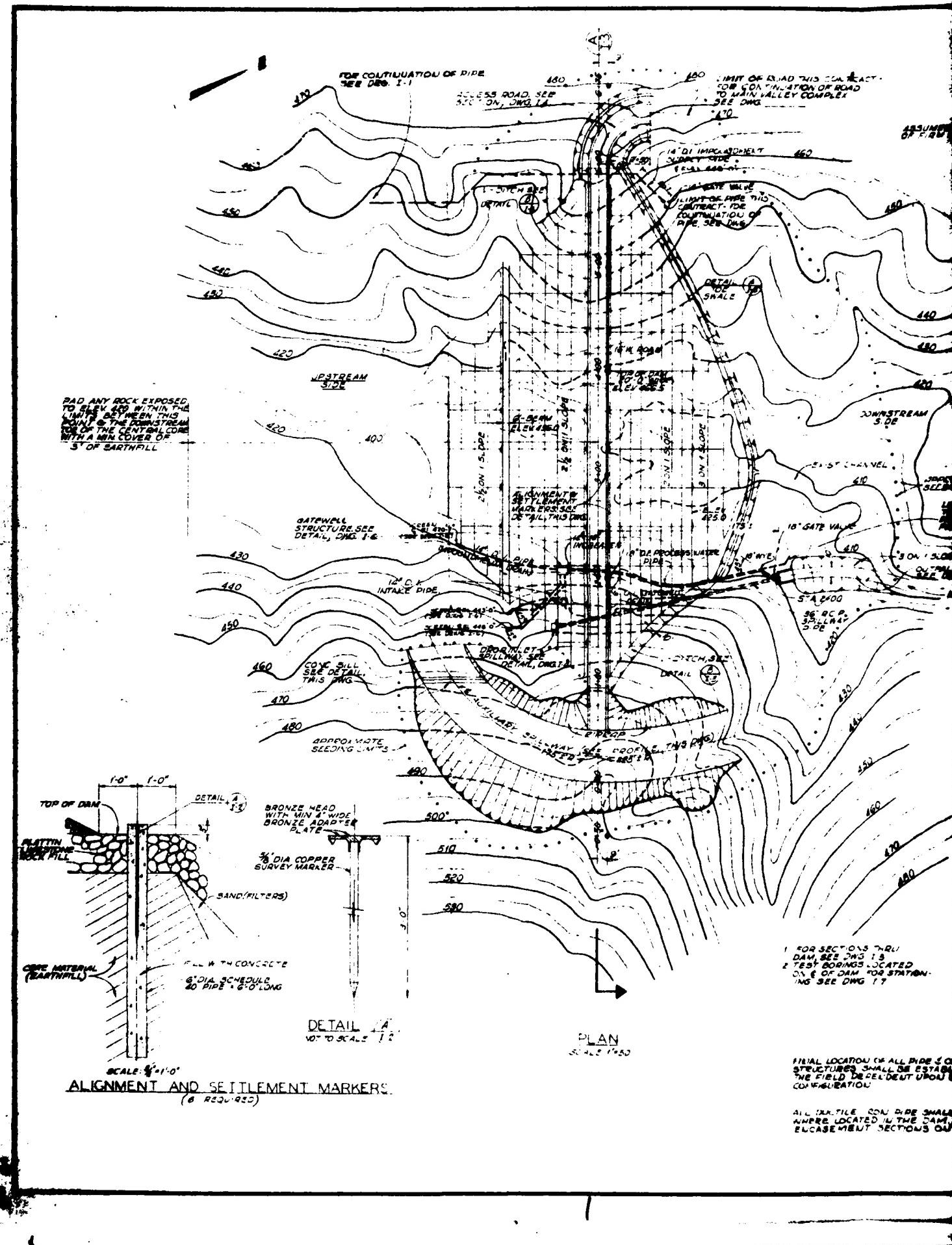


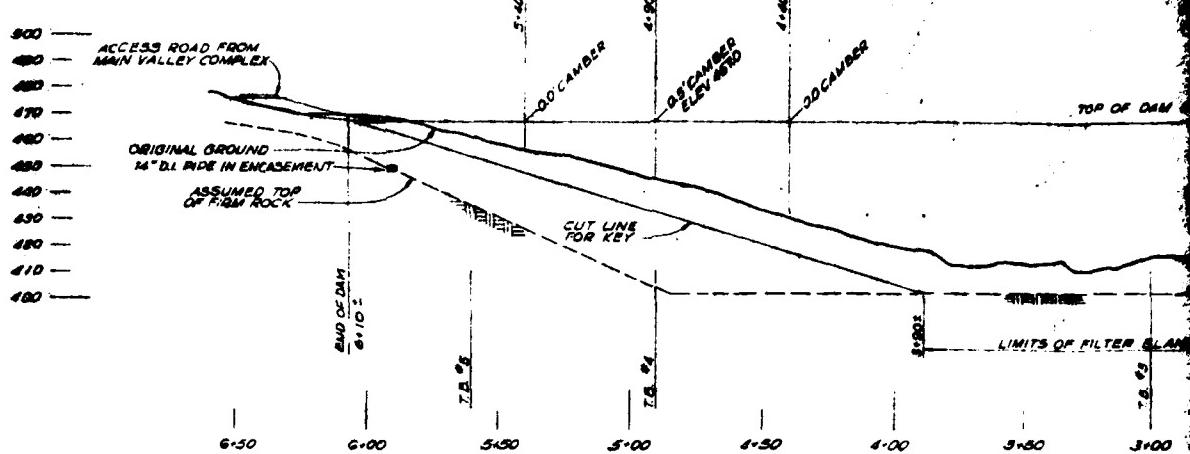
HORNERS
CONSULTANTS
ST. LOUIS

MISSOURI
CITY

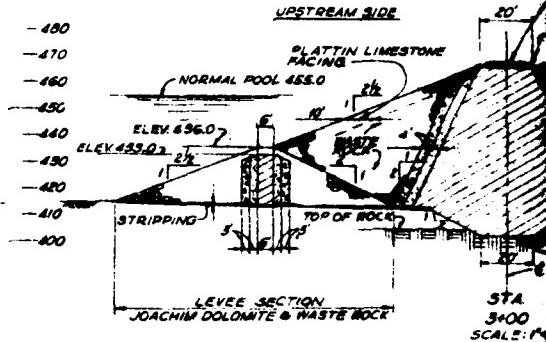
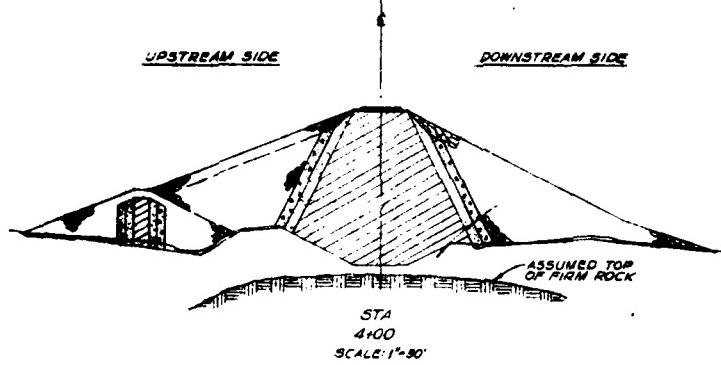
RIVER
MISSISSIPPI

PROCESS

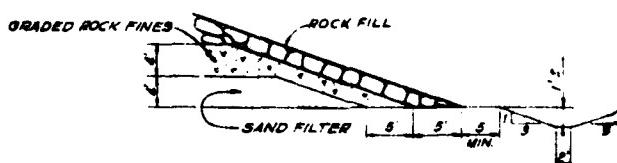
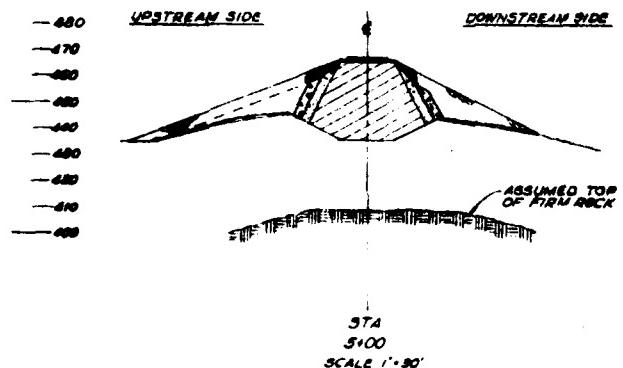




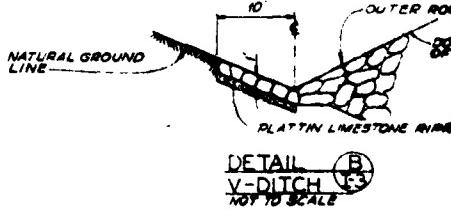
PROFILE A OF DAM (LOOKING



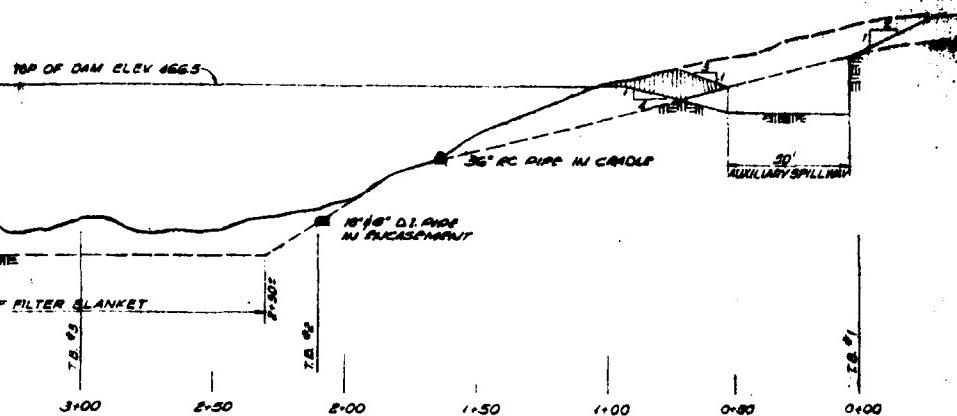
**NOTE. ALL DIMENSIONS
CONSTRUCTION
ON STATIONS
ARE SIMILAR.**



DETAIL A
TOE SWALE
NOT TO SCALE

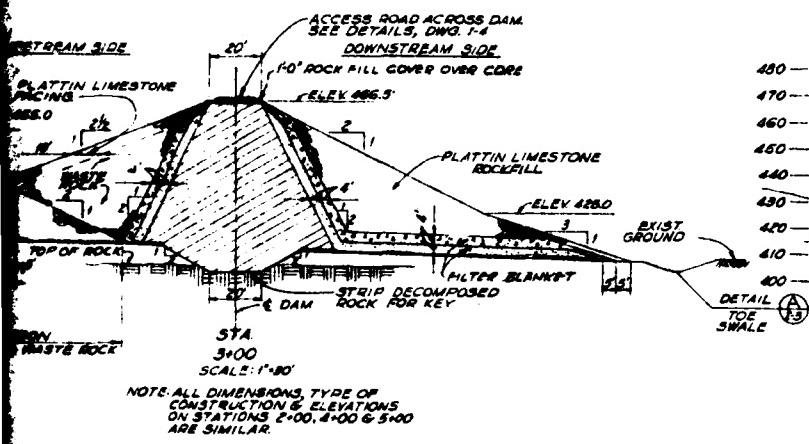


CROSS SECTIONS OF DAM



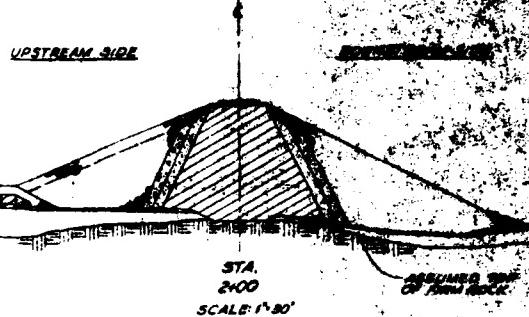
C. OF DAM (LOOKING DOWNSTREAM)

SCALE: 1"-30'



SCALE: 1"-30'

NOTE: ALL DIMENSIONS, TYPE OF CONSTRUCTION & ELEVATIONS ON STATIONS 2-00, 4-00 & 5-00 ARE SIMILAR.

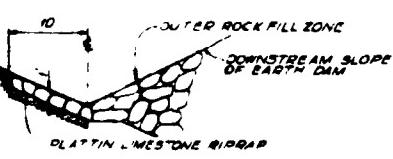


LEGEND

- CORE MATERIAL (CONCRETE)
- BAND (FILTERING)
- GRADED (ROCK MASS)
- ROCK FILL
- TEST BORING (SEE DING 1-7)



DETAIL A
TOE SWALE
NOT TO SCALE

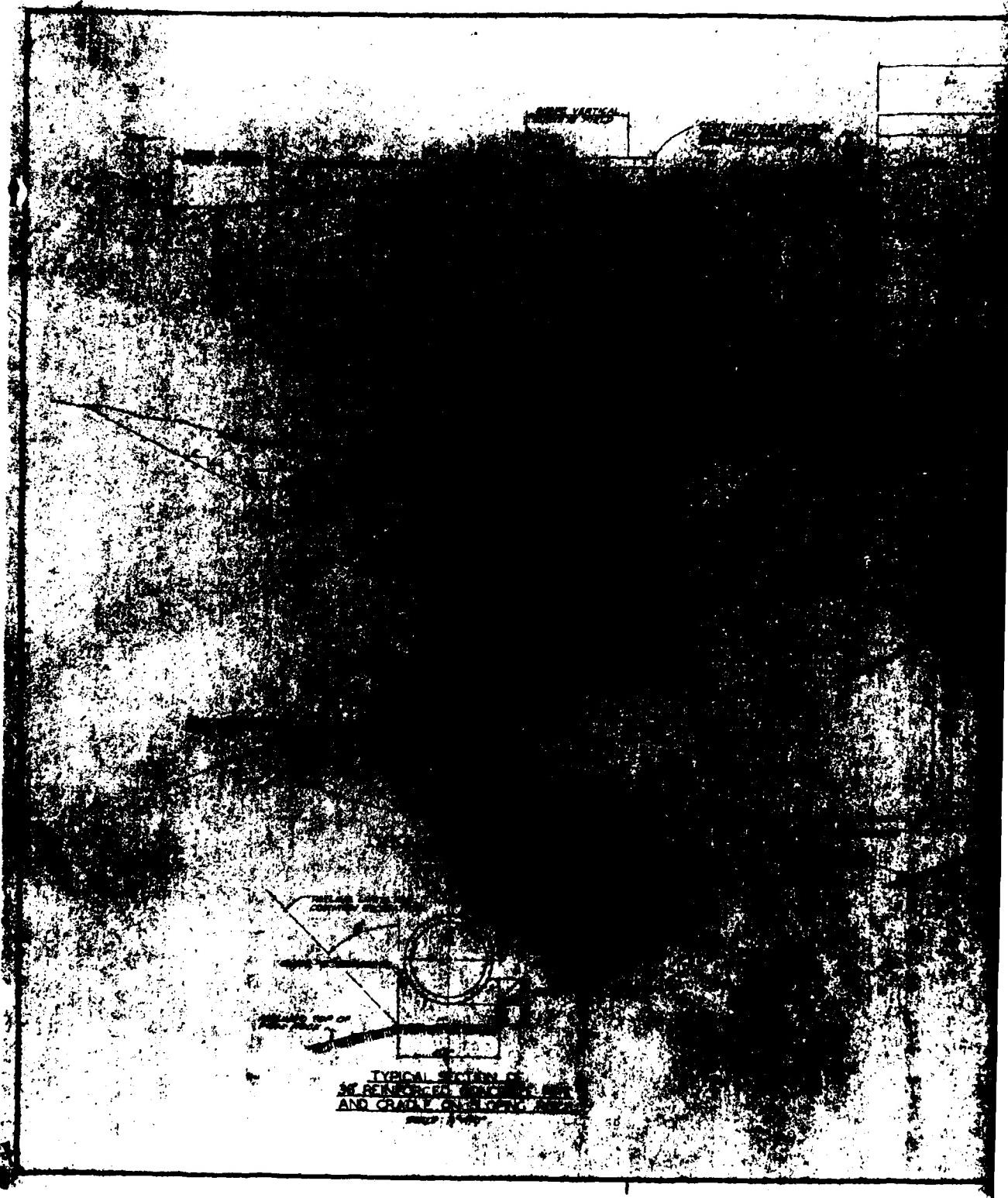


DETAIL B
V-DITCH
NOT TO SCALE

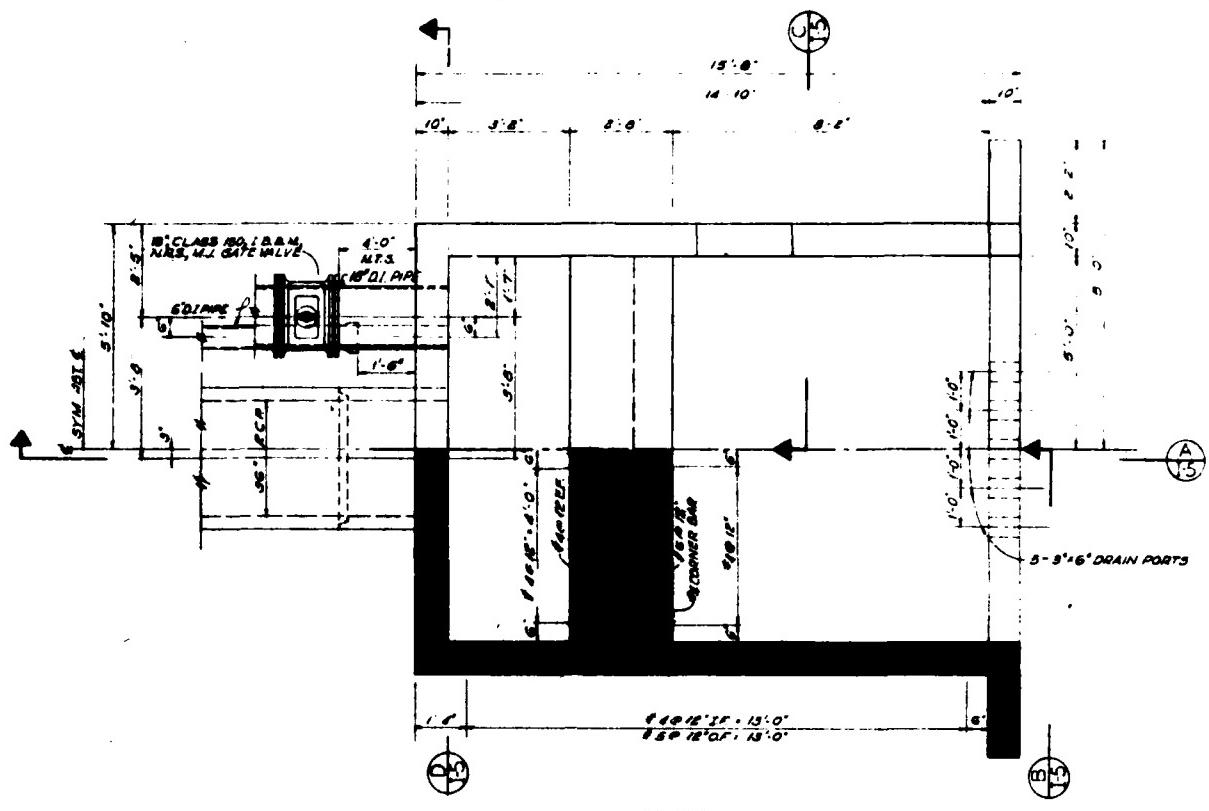


REVISIONS			
DATE	RED.	REMARKS	BY
A-11-14	J.	PRINCIPAL INCHES, 1/4 INCH	

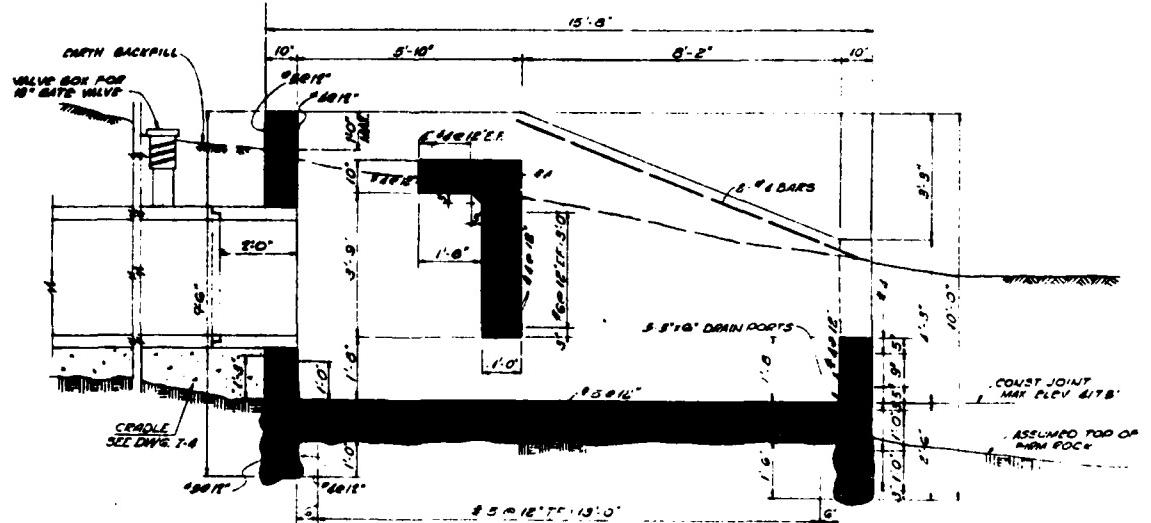
HORNER & SHAFRIN CONSULTING ENGINEERS ST. LOUIS, MO.	
MACDONALD ENGINEERS CHICAGO, ILLINOIS	
RIVER CEMENT CO. MISSISSIPPI RIVER & WASH. INDUSTRIES	
PROCESS WATER IMP. CROSS SECTIONS	
DET. NO. 102	DET. NO. 103
DET. NO. 104	DET. NO. 105
DET. NO. 106	DET. NO. 107
DET. NO. 108	DET. NO. 109
DET. NO. 110	DET. NO. 111







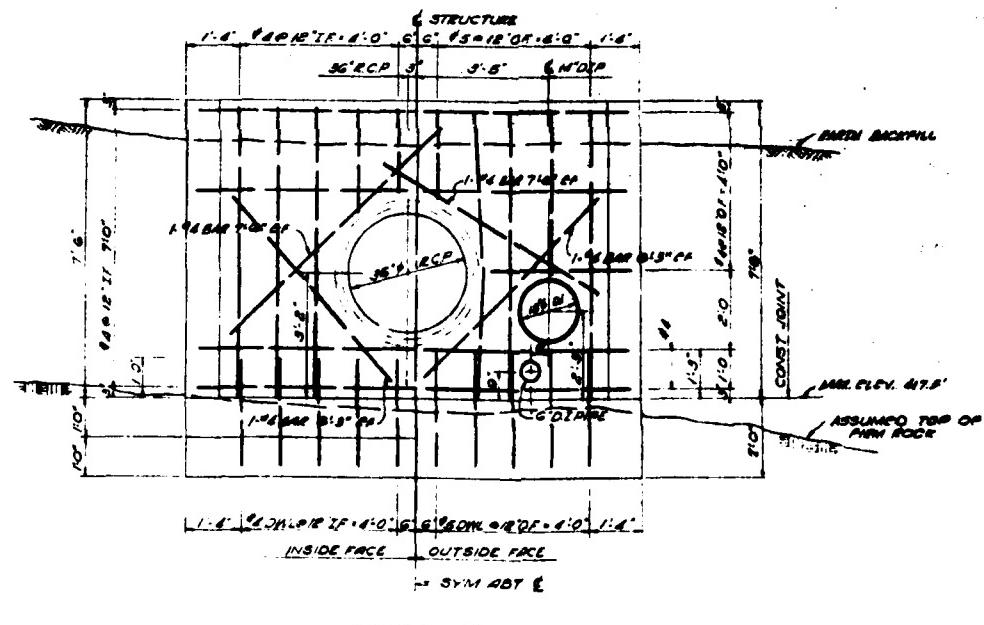
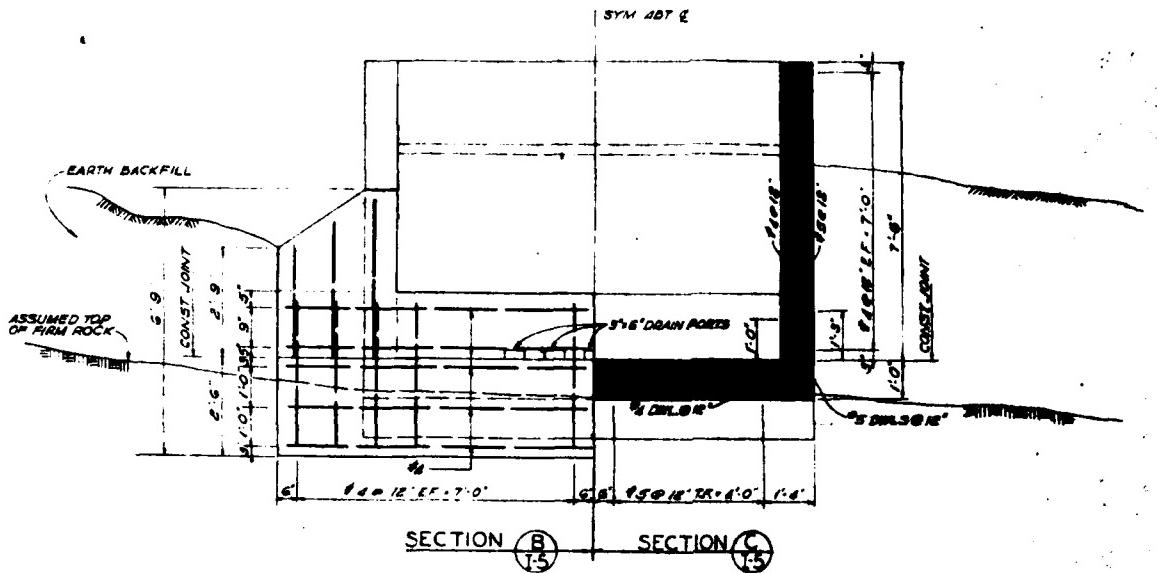
PLAN



SECTION A

NOTE: FOR DETAIL OF OUTRALL CHANNEL
SEE DWD :-

FINAL LOCATION AND ELEVATION OF THE
OUTRIGGER STRUCTURE SHALL BE DETERMINED
IN THE FIELD TO MEET ACTUAL ROCK
CONFIGURATION; HOWEVER, THE OUTRIGGER
FLOOR SHALL NOT BE CONSTRUCTED TO
AN ELEVATION GREATER THAN 3170'



~~ASSUMED TOO OF
FROM POCH~~

- ASSUNED TOO OF
- FROM POC &

- ASSUNED TOO OF
- FROM POC &

CHANNEL

POSITION OF THE
WILL BE DETERMINED
SPECIAL EDITION
OF THE STATEMENT OF
RECORDED TO
MAN 3274



**HORNER & SHIFRIN
CONSULTING ENGINEERS
ST. LOUIS, MO.**

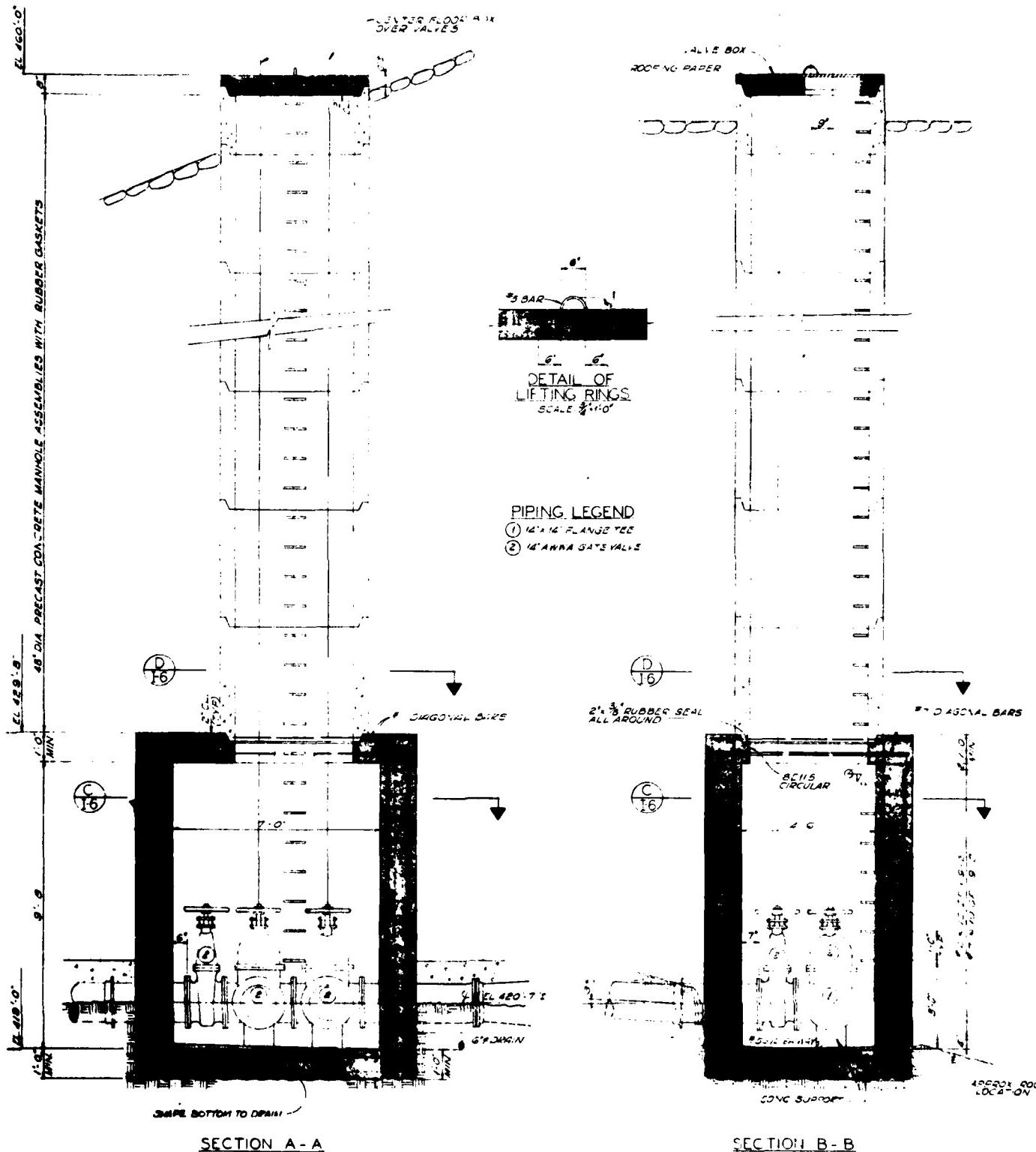
MACDONALD ENGINEERING CO.
CHICAGO, ILLINOIS
RIVER CEMENT CO.
DIVISION OF

MISSISSIPPI RIVER FUEL CO.,
SELMA, MO.

OUTFALL STRUCTURE

DRAWN BY J.W.F.	CHECKED BY G.H.L.
TRACED BY R.A.M.	APPROVED C.J.B.
DATE PRINTED	COMPLETED NO.
	5320

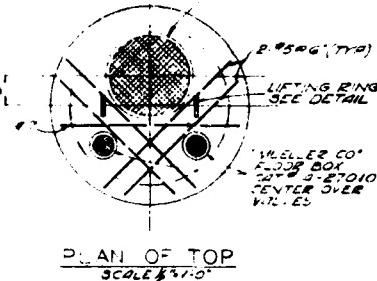
PIRATA



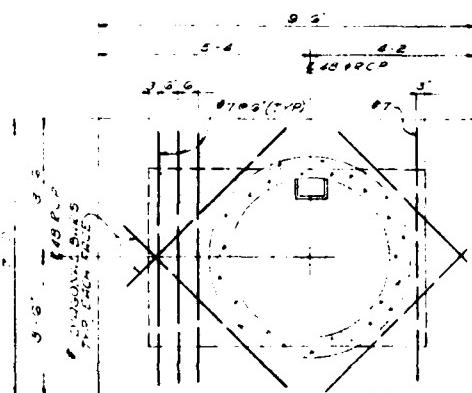
SECTION A - A

SECTION B - B
SCALE 8'-10"

WATER GROVE FDY
MH FRAME & COVER
CAT # A-1093

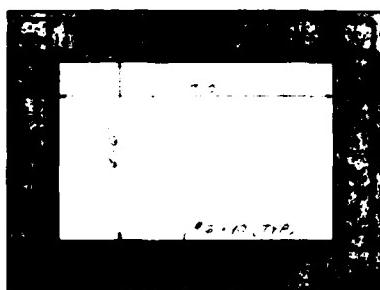


PLAN OF TOP



SECTION D-D

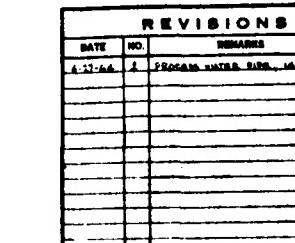
2-24321A BARS



SECTION C



426701 GOCE
Oct 4-04



HORNER & SHIFRIN
CONSULTING ENGINEERS
ST. LOUIS, MO.

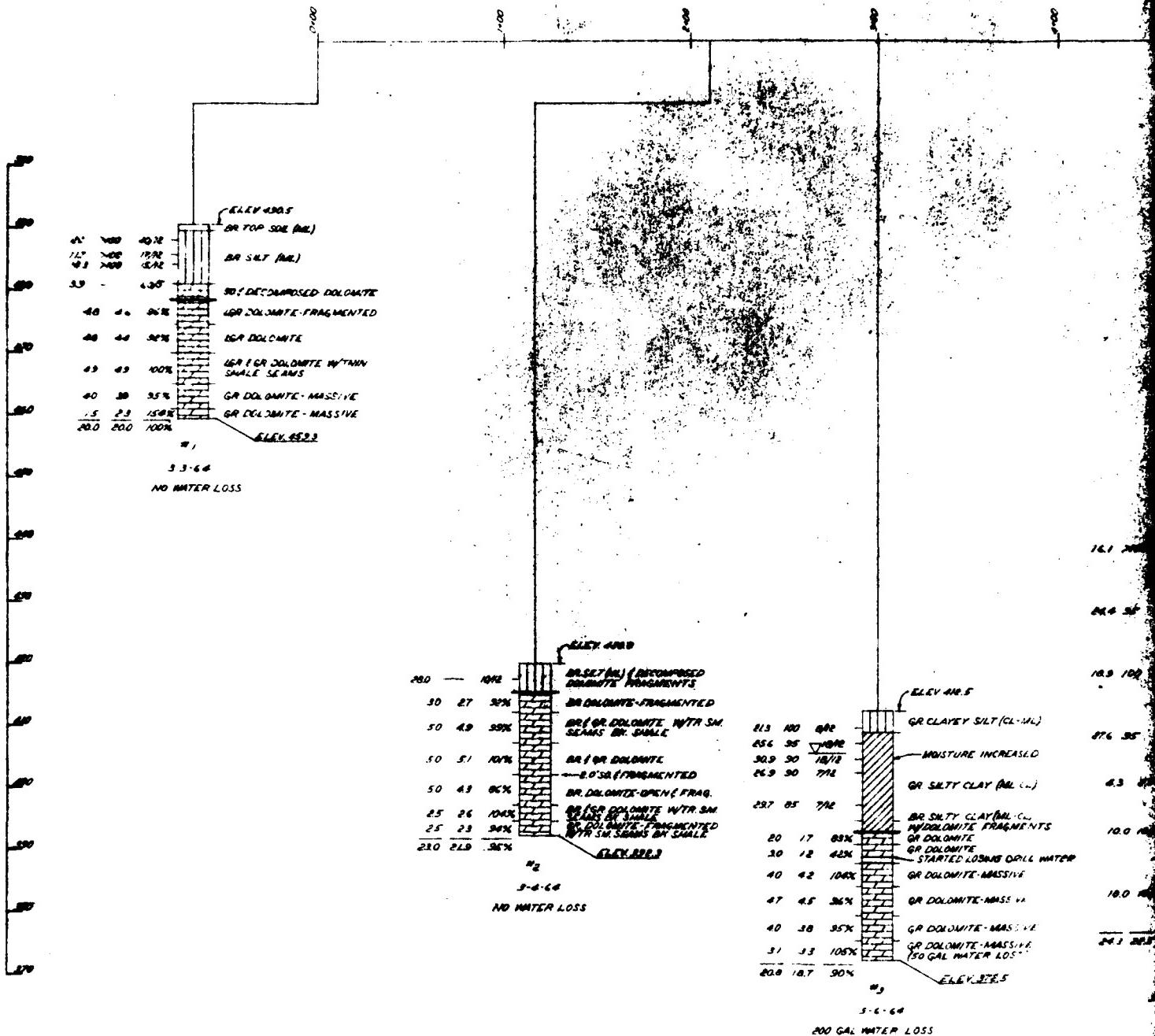
MACDONALD ENGINEERING CO.
CHICAGO, ILLINOIS

RIVER CEMENT CO.
DIVISION OF
MISSISSIPPI RIVER PUGA COMPANY
SELMA, MO.

**PROCESS WATER IMPOUNDMENT
GATEWELL STRUCTURE & MISC. DEP.**

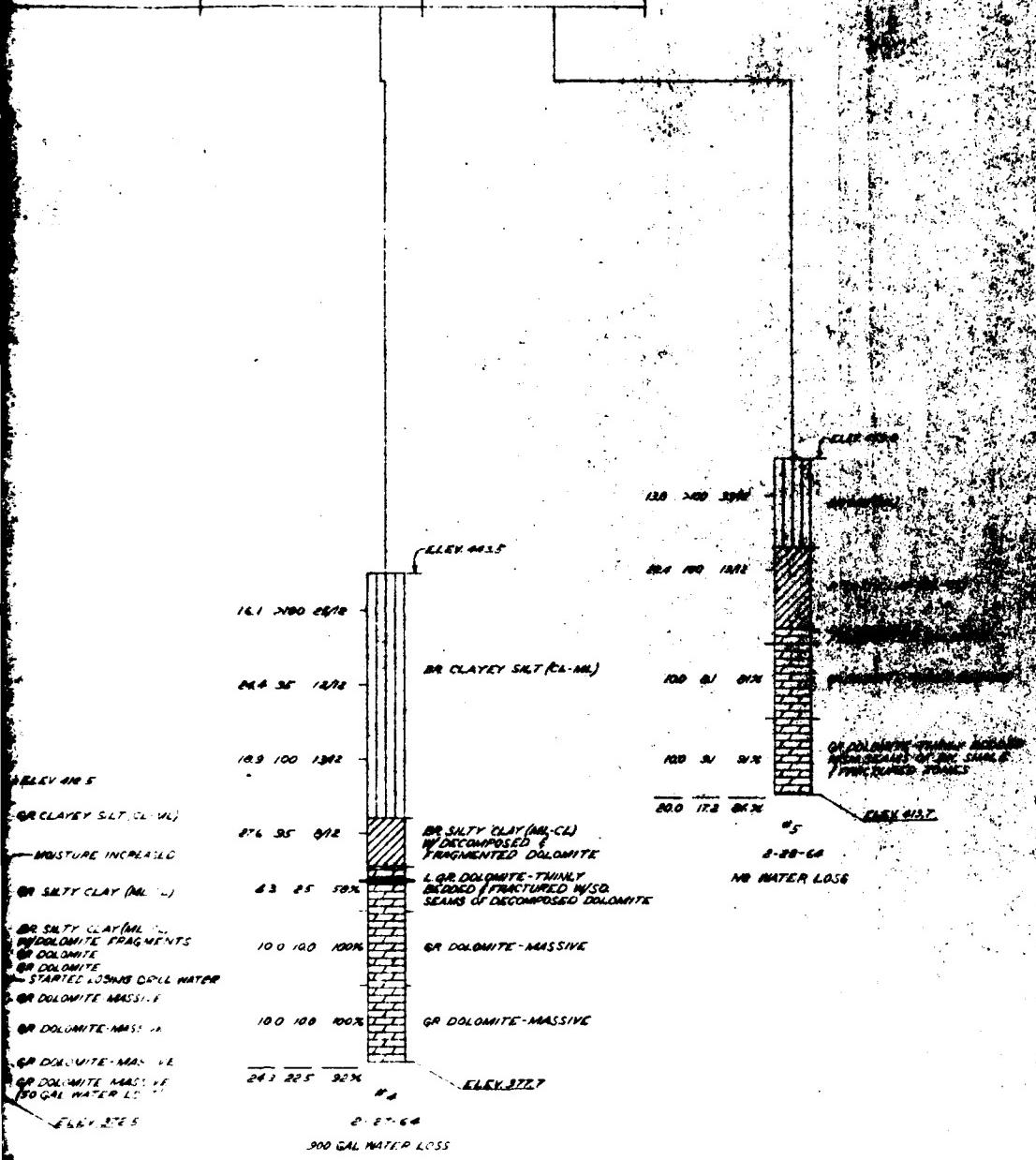
SEARCHED BY: BAH **SEARCHED BY: CWD (Date: 6/20/2013)**
INDEXED BY: BAH **INDEXED BY: CWD (Date: 6/20/2013)**

DATE ISSUED: COMMERCIAL NO: 0850



NOTE: PRESSURE TEST PERFORMED ON BORINGS "N" & "P"

DATE TESTED	6/1/64
BUCKET DEPTH	41'
ROUT MATURE	SHATTER CEMENT
(BY VOLUME)	SHATTER
ROUT TEST PRESSURE	5' 251
ROUT FLOW RATE	0' SALS
(MINUS VOLUME OF BOREHOLE)	



LOSS

BY APPROVAL OF COUNCILS " 26 " 4

6 GALS
 4 1/2 GALS
 WATER CEMENT
 50 PSI
 0 GALS.
 WATER CEMENT



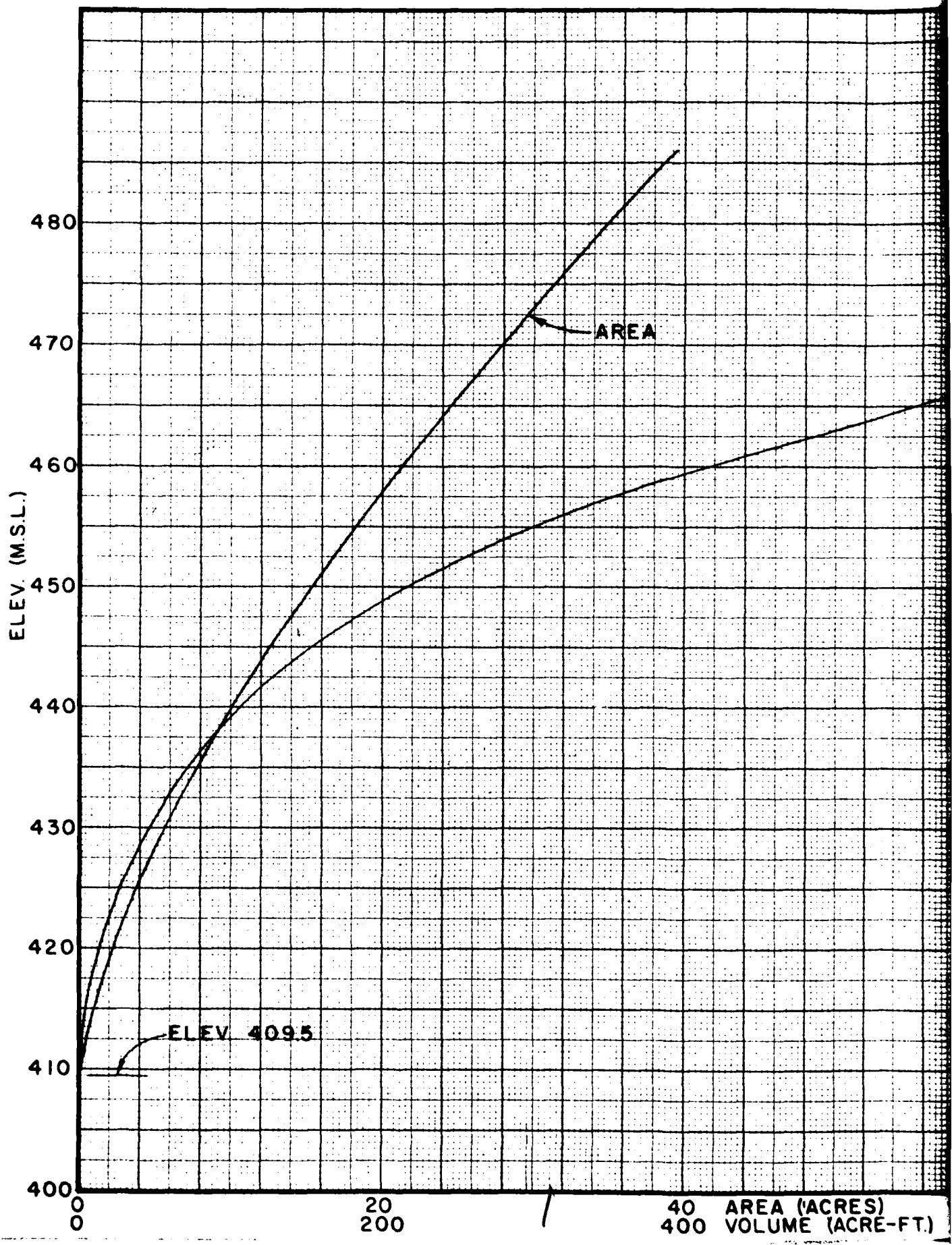
HORNER & SHIFFRIN
CONSULTING ENGINEERS
ST. LOUIS, MO.

MACDONALD ENGINEERING CO.
CHICAGO, ILLINOIS
RIVER CEMENT CO.
Division of
MISSISSIPPI RIVER FUEL CORP.

**PROCESS WATER IMPOUNDMENT
FOUNDATION BORING PROFILE**

DRAWN BY <u>W.E.</u>	DRAINED BY <u>C.W.H.</u>	DATE DRAWN <u>10/10/00</u>
BASED BY <u>C.S.D.</u>	APPROVED BY <u>C.W.H.</u>	DATE BASED <u>10/10/00</u>
DATE PRINTED <u>10/10/00</u>	CONTRACT NO. <u>C-270</u>	FILE NUMBER <u>107</u>

PLATE



STORAGE VOLUME

RIVER CEMENT CO. LAKE
AREA-STORAGE CURVES

Horner & Shifrin, Inc.

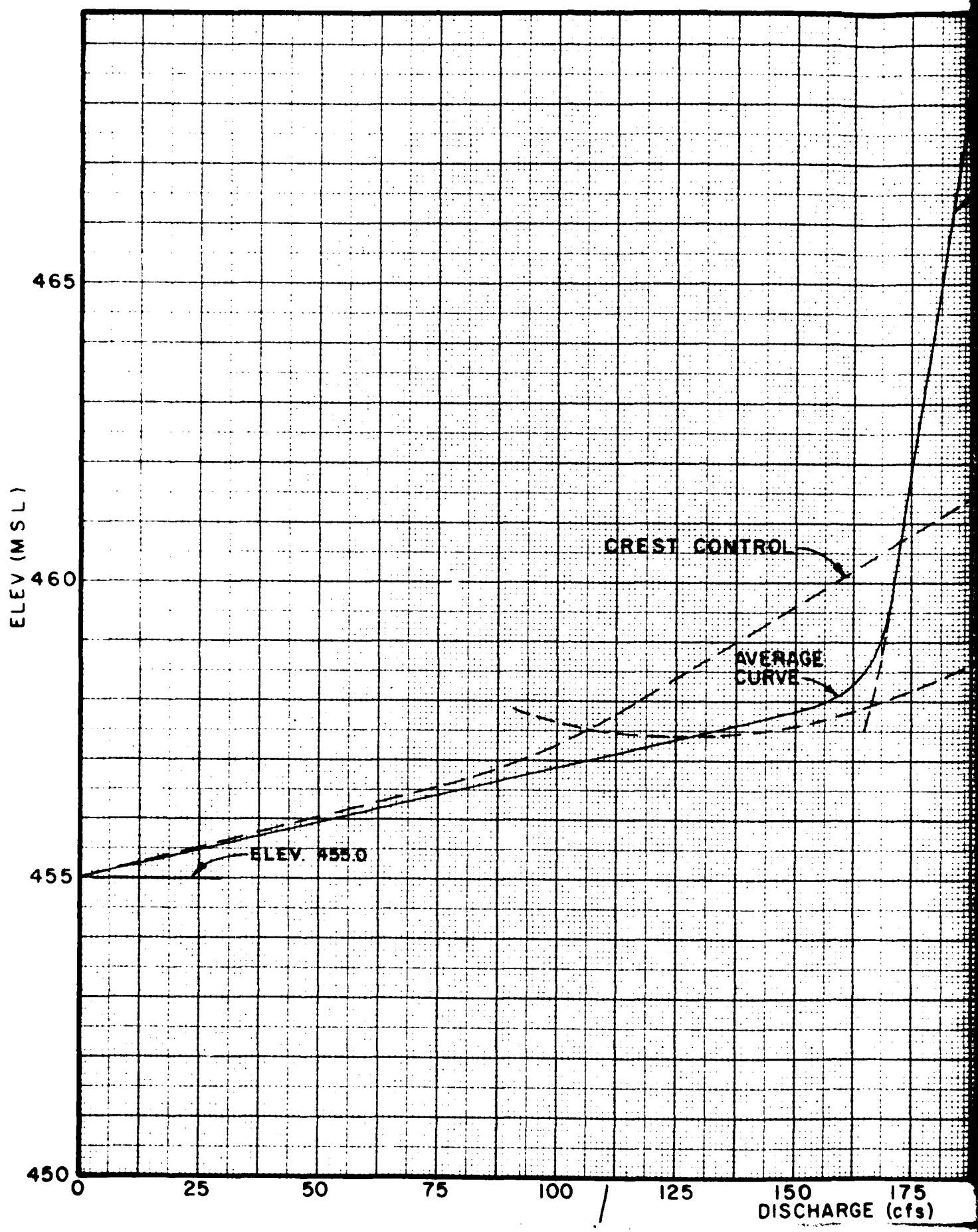
Sept. 1979

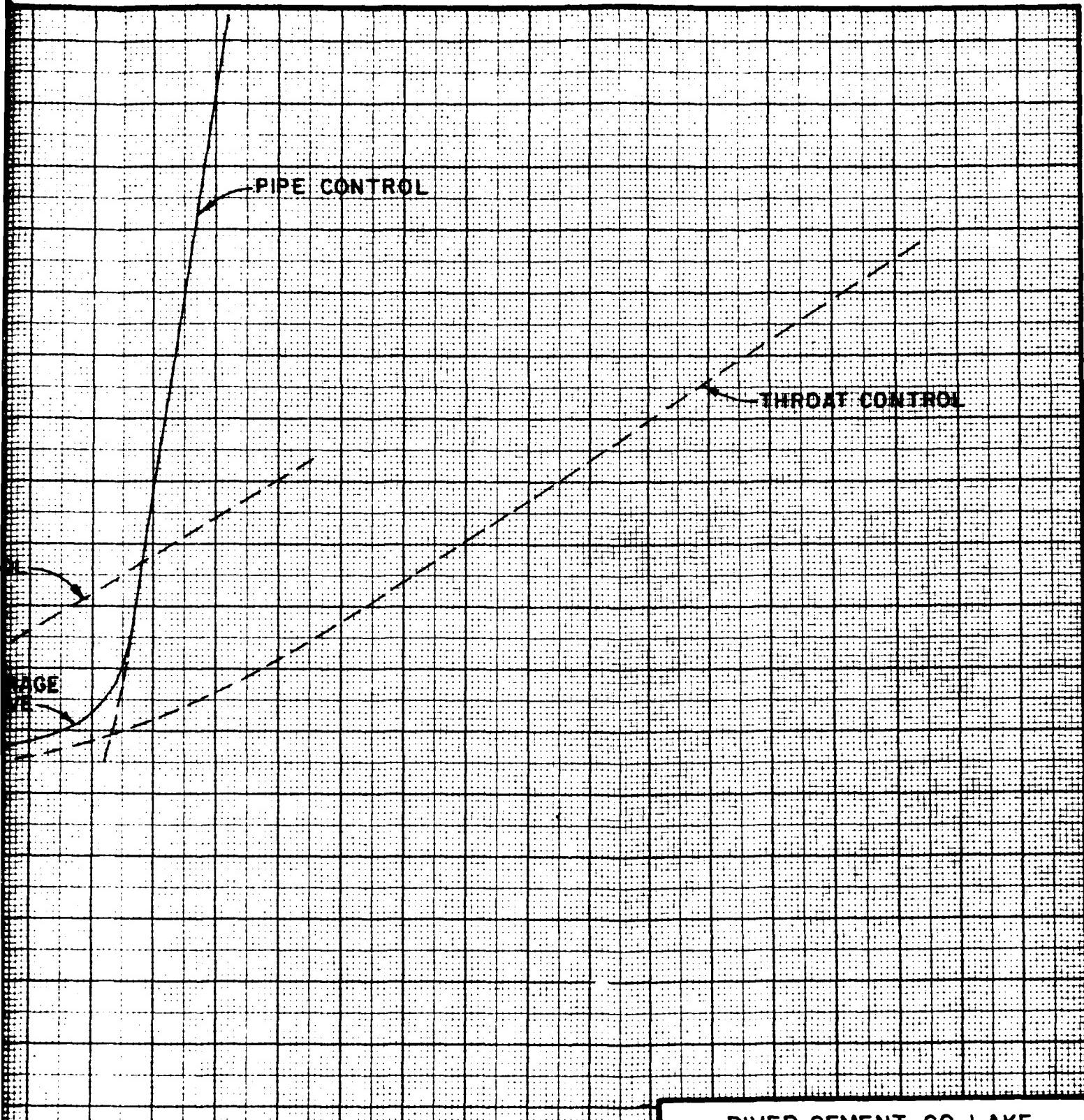
(ACRES)
60
600

80
800

100
1000

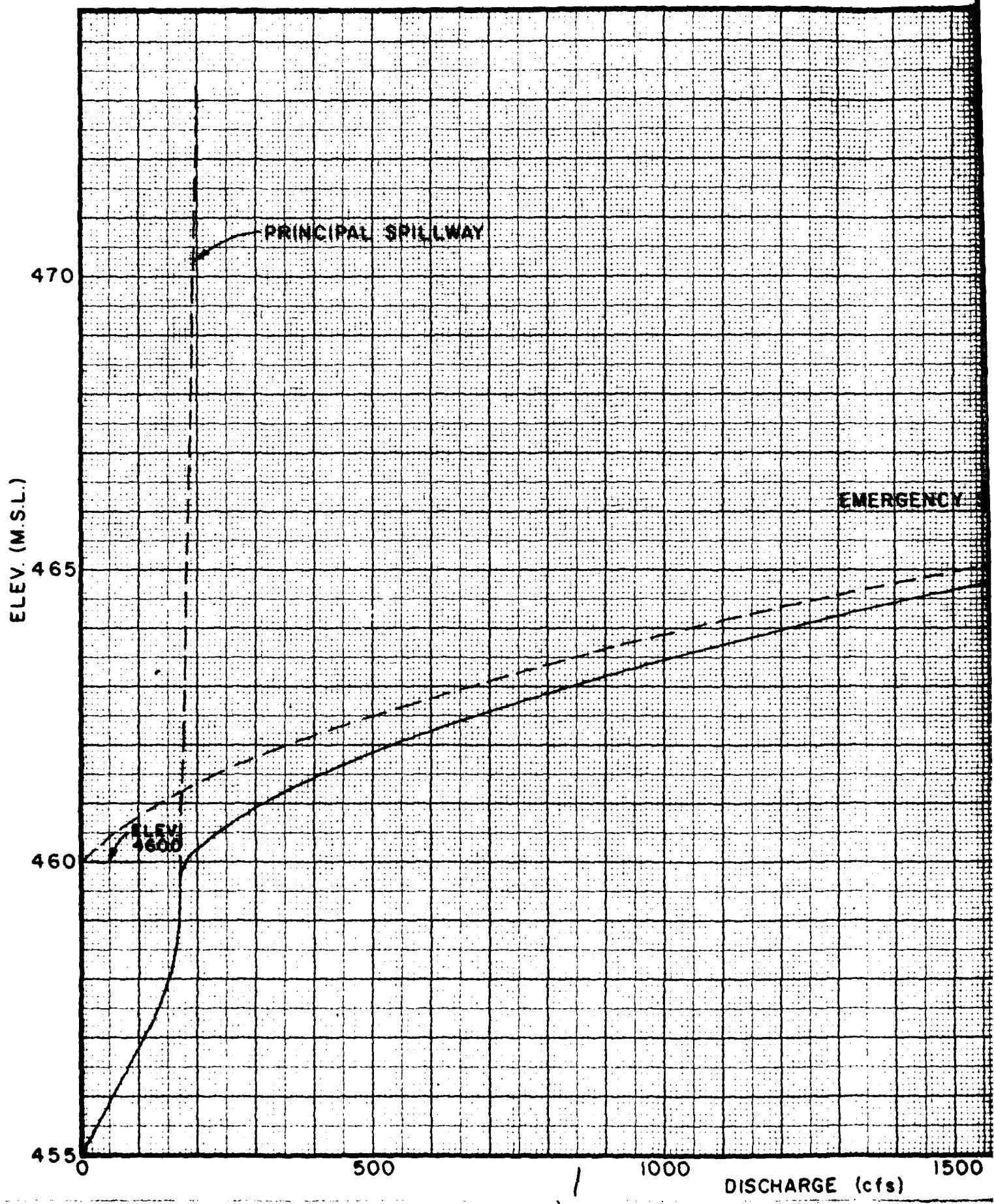
PLATE 10





RIVER CEMENT CO. LAKE
DISCHARGE RATING CURVES
PRINCIPAL SPILLWAY

Horner & Shifrin, Inc. Sept. 1979



EMERGENCY SPILLWAY

COMBINED SPILLWAYS

RIVER CEMENT CO. LAKE
DISCHARGE RATING CURVES
COMBINED SPILLWAYS

Horner & Shifrin, Inc.

Sept. 1979

1500

2000

2500

PLATE 12

ARGE (cfs)

ENGINEERING GEOLOGIC REPORT OF THE RIVER CEMENT COMPANY LAKE SITE

Jefferson County, Missouri

LOCATION: SE $\frac{1}{4}$, SE $\frac{1}{4}$, Sec. 22, T. 40 N., R. 6 E., 30th Quadangle.

The lake, constructed approximately 10 years ago, is in a small north-south trending tributary to Cliffdale Hollow. A daily capacity 3200 gallons of water per minute is pumped from the Mississippi River into the lake. The withdrawl is approximately 1700 gallons per minute. If without the large constant inflow of water the lake level drops. (Personal comment.)

No obvious leaks were noted downstream of the dam or resurgence of water in valleys to the east. The present bedrock in the lake area is dolomite of the Joachim Formation. The Joachim and the layers above and below are dipping rapidly to the east at a rate of approximately 100 feet per mile. If water is being lost in the bedrock below the lake waterline, it would not resurge prior to its entry into the Mississippi River.

Assuming that water from the lake is leaking into the bedrock, no remedial measures can be recommended until the points of infiltration are located. The bedrock exposed below the waterline is badly weathered and numerous cracks exist where water could possibly flow laterally or horizontally from the lake area.

From a surficial examination, the dam does not appear to be leaking. The large quantity of fill material below the dam may well be absorbing large quantities of water and transmitting it to the rock sections and areas of enough quantities that it is not observable the leakage.

The drainage area encompasses approximately 230 to 240 surface acres and should be sufficient to maintain a relatively stable waterline in a 15 to 25 acre lake, provided no withdrawl or leakage was occurring.

If in fact leakage is occurring, there are two probable sources of leakage:

- 1) Is through the dam via the trenches provided for the inlet and outlet pipes. Water may be moving through the dam on the outside of these pipes and soaked up in the large amount of fill material below the dam. The fill material would likely discharge this water to the stream in various points.

It is recommended that the water discharge from the two pipes from plant be monitored for a good estimate of flow at the points of discharge. The flow in the stream should then be measured downstream of the valley where the lake is situated but upstream of the next valley east. A stream measurement in this area would give a good indication whether the flow at the downstream point is equal to or very much larger than the total discharge from the plant. This should be done at a period when the stream upstream of the plant discharge is flowing very small quantities such as on the date of this investigation. If the stream flow downstream of the valley where the lake is situated is much larger than the total discharge from the plant, it can probably be assumed that water from the valley with the lake is contributing substantial quantities of water to the stream. If this should be the case, backhoe excavation at the pipelines, both inflow and outflow might reveal the source of leakage from the lake.

2). The second source of leakage would be horizontal leakage through bedrock eastward. If this is occurring, the water probably is not resurging on the surface due to the rapid eastward (and downward) dip of the rock. If this was occurring, the point of leakage might well be found by ceasing to pump water into the lake or withdrawing water from the lake. The lake should slowly recede. Careful observation on the east side should reveal the points of water loss.

The Joachim Formation does not normally have large joints or solution features that would allow rapid water loss from a lake. The lake setting is however, on the flank of a geologic structure that could have caused fracturing in this particular bedrock unit. Liniments on aerial photographs of the area are present and will be checked out in the field when time permits. A joint or vertical crack in the bedrock could well allow water to escape to the east and may be a single point source of water leakage.

An addendum to this report will be written after further investigation.

Thomas J. Dunn, Geologist
Applied Engineering & Urban Geology Section
Office of State Geologist
December 27, 1974

cc: Ken Sherman
River Cement Company
Selma Plant
Festus, Missouri 63028

Chart 2-2

16A

FOR FILE ONLY

16B

RIVER CEMENT LAKE SITE

JEFFERSON COUNTY

This is an addendum to the original report made by Tom Dean. On November 24, 1976, a field investigation was made on the excavation that River Cement Company had made on the north shore of the lake. The excavation was made where a recent small sinkhole had appeared in the silty clay surface soils just above the water line on the north edge of the lake.

The trench was approximately 20 feet long and from 4 to 8 feet deep. The deeper portion of the trench was near the west edge of the excavation. The trench exposed a weathered limestone that contained a horizontal solution enlarged joint. Numerous size clam shells were in the solution opening and were evidence that lake water was seeping through the soil on top of the joint and entering the joint opening. The enlarged joint ranged from two feet wide down to almost a hairline crack. It was widest near the east half of the trench and then became smaller towards the west edge of the trench.

It was suggested to Missouri River personnel that a concrete bulkhead be poured in front of the solution enlarged joint and that two inch pipe nipples be placed through the concrete. After the bulkhead had set a grout hose could be attached to the nipple and grout placed under pressure into the opening. A pressure gauge should be attached to the outside of the nipple so that grout pressures inside the joint will be known. After the pressures build up to 3 to 4 or 5 pounds per square foot, grouting could stop and be changed over to a new nipple.

JWW
John W. Whitfield, Geologist
January 14, 1977

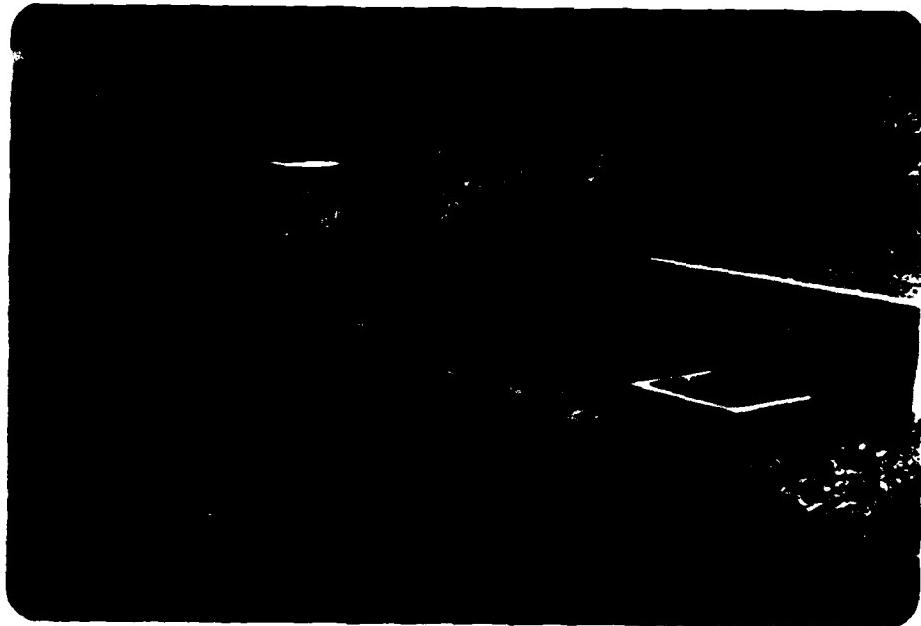
APPENDIX A
INSPECTION PHOTOGRAPHS



NO. 1: UPSTREAM FACE OF DAM



NO. 2: DOWNSTREAM FACE OF DAM



NO. 3: DROP INLET SPILLWAY AND GATEWELL



NO. 4: SPILLWAY OUTFALL STRUCTURE



NO. 5: UPSTREAM END OF AUXILIARY SPILLWAY



NO. 6: DOWNSTREAM END OF AUXILIARY SPILLWAY



NO. 7: TAILWATER POOL BELOW DAM



NO. 8: BEAVER DAM ACROSS DOWNSTREAM CHANNEL

APPENDIX B

HYDROLOGIC AND HYDRAULIC ANALYSES

HYDROLOGIC AND HYDRAULIC COMPUTATIONS

1. The HEC-1 Dam Safety Version (July 1978, Modified 26 February 1979) program was used to develop inflow and outflow hydrographs and dam overtopping analyses, with hydrologic inputs as follows:

a. Probable maximum precipitation (200 sq. mile, 24-hour value equals 25.5 inches) from Hydrometeorological Report No. 33. The precipitation data used in the analysis of the 1 percent (100-year flood) was provided by the St. Louis District, Corps of Engineers.

b. Drainage area = 0.41 square miles = 263 acres.

c. SCS parameters:

$$\text{Time of Concentration } (T_c) = \left(\frac{11.9L^3}{H} \right)^{0.385}$$

Where; T_c = Travel time of water from hydraulically most distant point of interest, hours.

L = Length of longest watercourse, miles.

H = Elevation difference, feet.

Lag time = 0.092 hours (0.60 T_c)

*Soil type CN = 61 (AMC II, 100-yr flood condition)
= 78 (AMC III, PMF condition)

*Based on estimated clay content of samples obtained on site.

2. Spillway releases for the drop inlet spillway were computed utilizing equations and nomographs presented in "Design of Small Dams" by the U.S. Department of the Interior for morning-glory type spillways. The perimeter of three sides of the square inlet was equated to a circular section in order to determine a radius for use in the equations.

The rise of the nappe above the elevation of the crest lip was considered negligible. The following equation was used for crest control:

$$*Q = C_o (2 \pi R_s) H_o^{3/2}$$

where " C_o " is a coefficient expressed in terms of H_o/R_s , " R_s " is the radius of the spillway crest, " H_o " is the depth of flow over the crest.

When the ratio H_o/R_s reached a value of 1.00, inflow was determined by assuming flow was over a sharp edged submerged orifice. The following equation was used: $Q = Ca (2gh)^{0.5}$, where "C" is a coefficient, "a" is the area of the orifice, "h" is the height of flow above the orifice, and "g" is acceleration due to gravity.

Flow through the 36-inch diameter outlet pipe was determined using Bernoulli's equation for pressure flow in pipes. Losses, including throat, entrance, pipe and exit losses totaled 3.47 velocity heads.

Discharge quantities, determined by the methods described herein were plotted versus corresponding lake water surface elevations with the best fit combination of the three plots being the discharge rating curve for the drop inlet spillway.

3. The auxiliary spillway section consists of a broad-crested, U-shaped rock cut section for which conventional weir formulas do not apply.

Spillway release rates were determined as follows:

- a. Spillway crest section properties (area, a and top width, t) were computed for various depths, d.
- b. It was assumed that flow over the spillway crest would occur at critical depth. Flow at critical depth Q_c was computed as $Q_c = \frac{(a^3 g)^{0.5}}{t}$ for the various depth, d. Corresponding

*Reference: "Design of Small Dams," USDI Water Resources Technical Publication.

velocities (v_c) and velocity heads (H_{vc}) were determined using conventional formulas.

c. Static lake levels corresponding to the various values passing the spillway were computed as critical depths plus critical velocity head ($d_c = H_{vc}$), and the relationship between lake level and spillway discharge was thus obtained. The procedure neglects the minor insignificant friction losses across the length of the spillway.

4. The profile of the dam crest is irregular and flow over the dam cannot be determined by conventional weir formulas. Crest length and elevation data for the dam crest proper were entered into the HEC-1 Program on the \$L and the \$V cards. The program computes internally the flow over the dam crest and adds this flow to the flow passing the spillways as entered on the Y4 and Y5 cards.

5. A listing of the HEC-1 (Dam Safety Version) input data for routing the probable maximum flood and the 1 percent chance (100-year frequency) flood is shown on Pages B-4 and B-5 of the Appendix. A copy of the computer output table entitled "Summary of Dam Safety Analysis" is presented on Page B-6, and the inflow and outflow hydrographs for the probable maximum flood are shown on Page B-7 of the Appendix. Area-storage volume curves for the reservoir are presented on Plate 6 and the spillway discharge rating curves are shown on Plates 11 and 12.

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SUMMARY OF DAM SAFETY ANALYSIS - RATIOS OF PMF

ELEVATION STORAGE OUTFLOW	INITIAL VALUE 455.00 300.	SPILLWAY CREST 455.00 300. C.O.	TOP OF DAM 466.40 558. 2542.
RATIO OF PMF TO S.ELEV	MAXIMUM DEPTH OVER DAM 462.52 466.38	MAXIMUM STORAGE AC-FT 9.02 0.00	DURATION OVER TOP HOURS 561. 557.
		MAXIMUM OUTFLOW CFS	TIME OF FAILURE HOURS 0.00 0.00

SUMMARY OF DAM SAFETY ANALYSIS - 100-YR. FLOOD

ELEVATION STORAGE OUTFLOW	INITIAL VALUE 455.00 300. C.O.	SPILLWAY CREST 455.00 300. C.O.	TOP OF DAM 466.40 558. 2542.
RATIO OF PMF TO S.ELEV	MAXIMUM DEPTH OVER DAM 456.84	MAXIMUM STORAGE AC-FT 0.00	DURATION OVER TOP HOURS 135.
		MAXIMUM OUTFLOW CFS	TIME OF FAILURE HOURS 0.00 0.00

RIVER CEMENT CO. LAKE
PMF INFLOW & OUTFLOW
HYDROGRAPHS

Horner & Shifrin, Inc.

1979

